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May 2002

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NASA's Plan for Getting to the Last Planet

Are We Living in a 10-dimensional Universe? Probably. (p. 34)

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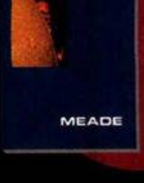
Right-to-left: Meade 8", 10", and 12" LX200GPS Schmidt-Cassegrain telescopes. Manufactured under U.S. Patent No. 6,304,376; other patents pending in the U.S.A. and worldwide.



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Meade® LX200GPS: the most important advance in Schmidt-Cassegrain technology in ten years is here.

For the visual observer, the astrophotographer, the CCD imager: all the telescope you could possibly have imagined.

For the advanced amateur, new Meade LX200GPS telescopes offer absolutely state-of-the-art optical, mechanical, and electronic performance unmatched by any competing models. Standard-equipment features include:

Precision GPS Alignment: Telescope alignment is accomplished automatically using integrated true-level and North electronic sensors in combination with a 16-channel GPS receiver located in the left-hand fork arm. Magnetic declination compensation is designed into the software and automatically engaged. Just press the *ENTER* button on the Autostar II hand controller and watch as the telescope slews at 8°/second to its first alignment star. *Competing GPS telescopes use a 12-channel receiver (resulting in slower and less reliable position acquisition), do not include any magnetic declination compensation, and can easily result in first-alignment-star errors of up to 20° or more.*

All LX200GPS models include the Zero Image-Shift Microfocuser as standard equipment. The primary mirror lock-knob is located directly above the manual focus knob.

Revolutionary new rear-cell systems designed for the advanced visual observer, astrophotographer and CCD imager — systems that enable new levels of precision in focusing in all applications and in image centering on CCD chips:

Primary Mirror Lock: Flip a knob located just above the manual coarse-focus knob and lock the telescope's primary mirror rigidly in place. Used in conjunction with the Zero Image-Shift Microfocuser *(below)* the primary mirror lock cancels any residual image shift while focusing during visual, photographic, or CCD imaging applications.

Zero Image-Shift Microfocuser: Now you can obtain the most precise image focus possible — truly to a microscopic level — during visual and astrophotographic applications, and, during CCD applications, simultaneously maintain precise image centration on even the smallest CCD chips. Included as standard equipment with all LX200GPS Schmidt-Cassegrain models, the Meade Zero Image-Shift Microfocuser operates at 4 different speeds from extremely slow to fast and is actuated through the Autostar II handbox. Coarse manual focusing is effected through the telescope'

Autostar II: The new Autostar II control system provided with LX200GPS models includes all of the features that made previous LX200 models the largest-selling serious telescopes in the world. In addition, Autostar II includes an expanded 3.5 Megabyte memory, with a greatly enlarged database of more than 145,000 celestial objects, a database that is immediately accessible on the Autostar II display. A partial listing of the Autostar II database:

Library	No. of Objects
New General Catalog (NGC)	7840
Index Catalog (IC)	5386
Uppsala Galaxy Catalog	12,940
Morphological Catalog of Galaxies	12,939
General Catalog of Variable Stars	28, 484
SAO and Hipparcos Star Catalogs	42,277
Draper Star Catalog (HD)	21,127
Yale Bright Star Catalog (BSC5)	6150
Large Bright Quasars Survey (LBQS)	1055
Messier Catalog (M)	110
Caldwell Catalog	109
Named Objects	227
Herschel Catalog	400
Abell Catalog of Galaxy Clusters	2712
Arp Catalog of Irregular Galaxies	645
Major planets from Mercury to Pluto	8

SPECIFICATIONS: 7", 8", 10", and 12" LX200GPS — Each complete telescope includes 8", 10", or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens; standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); primary mirror lock; 4-speed zero image-shift microfocuser; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and 7-port multi-function control panel, including two RS-232 serial interface ports; manual and electric slow-motion controls on both axes; Autostar II control system with 3.5-Megabyte flash memory, digital readout display, permanently programmable Smart Drive and 185-speed drive controls on both axes, High-Precision Pointing, and GO TO controller; 145,000-object onboard celestial software library; GPS alignment system with 16-channel GPS receiver, magnetic declination compensation, and true-level and North electronic sensors; 12vDC telescope power supplied from internal battery compartments accepting 8 (user-supplied) C-cells (optional 25 ft. cords available for powering from auto cigarette lighter plug or from 115vAC); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

MEADE LX200GPS SCHMIDT-CASSEGRAIN TELESCOPES

8" LX200GPS	**$2495**
10" LX200GPS	**2995**
12" LX200GPS	**3995**
7" LX200GPS Maksutov-Cassegrain	**2995**

Ultra-High Transmission Coatings (UHTC) group *(see ad in this issue)*: 8" LX200GPS – $175; 10" LX200GPS – $235; 12" LX200GPS – $295; 7" LX200GPS – $150.

Packing & shipping charges in the 48 states: 8" – $105; 10" – $145; 12" – $215; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices.

A COMPARISON OF GPS SCHMIDT-CASSEGRAIN TELESCOPES

	Meade LX200GPS	Competing 11" GPS*
GPS Receiver	16-channel	12-channel
Magnetic declination compensation	yes	no
True-level electronic sensor	yes	no
Primary mirror lock	yes	no
Zero image-shift microfocuser	yes	no
Maximum slew speed	8°/second	3°/second
Number of drive speeds, each axis	185 speeds, from .01x sidereal to 8°/sec.	9 speeds, from 0.5x sidereal to 3°/sec.
Number of tracking rates	sidereal, lunar, or custom-selected from 2000 rates	sidereal, lunar, or solar
Memory	3.5-Meg flash	1.0-Meg flash
GO TO pointing precision	2-arcmins	unstated
High-precision pointing mode	yes; permits GO TO pointing precision within 1-arcmin	no
Permanent Periodic Error Correction	yes, both axes	one axis only; second axis unprogrammable
Object database	147,541 objects	"40,000+"
Encoder resolution	0.14 arcsecs	0.26 arcsecs
Internal battery compartments for battery powering	yes; batteries located internal to fork arms	no
RS-232 software download	yes; object libraries and software downloads available	not currently available on factory website**
Tracking calibration	not required	recommended after changes in telescope position or load

*Based on sample and instruction manual received in 7/01. ** As of 2/5/02.

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May 2002 • Vol. 30, No. 5

Astronomy®

Cover Illustration: *Astronomy:* Elisabeth Rowan

FEATURES

34 **When Branes Collide**
Do extra dimensions explain some of the mysteries of the universe? Or do they create more mysteries? *Steve Nadis*

40 **Beyond the Pale**
Stars hide a wealth of information about the universe encoded in their colors. *Neil F. Comins*

COVER

46 **Pluto or Bust**
Finally, a mission seems sure to head off for the last great unexplored world in our solar system. *Andrew Cheng*

62 **Russian-Made Telescopes**
New imports from LOMO America, the company responsible for Russia's largest optical projects, offer Maksutovs for North American observers. *Phil Harrington*

66 **Celestial Portraits: Canes Venatici**
A constellation highlighted by the Whirlpool Galaxy also holds many other bright star systems along with a pretty impressive globular cluster. *Tom Polakis*

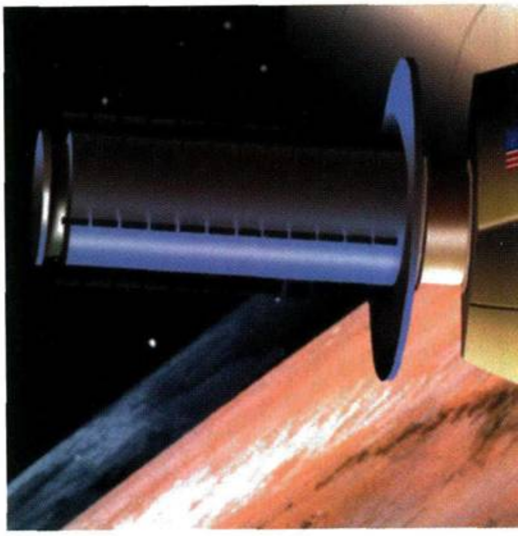
80 **Ask Astro**
The editors of *Astronomy* answer your questions about the sky and the universe.

66 Celestial Portraits

From *The Glorious Constellations*, c 1991, Harry N. Abarms, Inc.

22 AstroNews

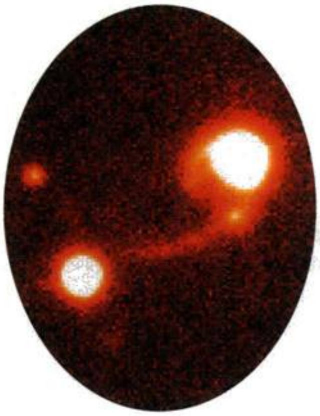
Jodrell Bank Observatory



40 Beyond the Pale

John Chumack

DEPARTMENTS



80 **Ask Astro**
ESO

6 **Behind the Scenes**
- Getting to the Last Planet

14 **Sky Gem**

16 **Talking Back**

22 **AstroNews**
- What Color is Your Universe?
- Amateurs Score Space Telescope
- Measuring-up to the Moon
- Space May Not Be So Wet
- New Neighbors for the Sun
- Cryobot Gets Ready for Space

46 **Pluto or Bust** Dan Durda

52 **Sky Show**
- Don't miss the planetary grouping of the decade. *Martin Ratcliffe and Alister Ling*

72 **Astronomy 101**
- Diary of a Neophyte Astronomer

76 **The Savvy Astronomer**
- Catch an Extrasolar Planet

82 **Star Stuff**

Products
- Spectrum Filter Wheel
- Tele Vue Carry Bag
- Nagler Zoom Eyepiece

Books
- *Great Physicists: The Life and Times of Leading Physicists from Galileo to Hawking*
- *Encyclopedia of Astronomy and Astrophysics*

Bytes
- Northern Observatories Virtual Tour

90 **Strange Universe**

92 **Looking Ahead**

94 **Advertiser Index**

100 **Hot Shots**
- Persian Stars

104 **Ultimate Exposure**

62 **Russian-Made Telescopes**
Astronomy: Bill Zuback

34 **When Branes Collide** Science Photo Library

BEHIND THE SCENES

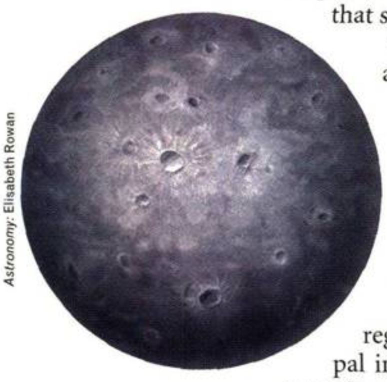
BY BONNIE BILYEU GORDON

Getting to the Last Planet

Pluto is the last largely unexplored planet in our solar system. We currently know precious little about this tiny rock; even the Hubble Space Telescope photographs of the last planet show it as a kind of blue-green ball with smudged edges. In fact, it's not always the last planet, as every 250 years or so, it changes position with Neptune for 20 years, becoming the 8th planet and leaving Neptune in the outside position. This is because it has a highly elliptical orbit that varies in length by about 2 billion miles.

We know that Pluto is accompanied by a moon about half its size, a moon called Charon. Because of that, some people call the system a double planet. We also are pretty sure both little planets are encased in ice.

Pluto has been at the center of a debate on just what defines a planet. Some researchers think of it as not so much a planet as a very large asteroid, circling the sun in the busy lanes of the Kuiper Belt. Some distant asteroids have been detected that seem to be almost as large as Pluto.


Astronomy: Elisabeth Rowan

Such checkered knowledge, however, serves as a spur to planetary scientists, who very badly want to send a spacecraft to Pluto. Talk of such a mission is well underway at NASA. And it was the subject of a good deal of discussion at this year's winter meeting of the AAS. It seems now as if funding for a mission to Pluto has advanced from the dream stage to reality.

Planetary scientist Alan Stern, who is a regular contributor to *Astronomy*, is the principal investigator for New Horizons, a mission that promises to "Shed Light on the Frontier World." The Stern team wants to send global mapping and high-resolution imaging equipment to get a close look at Pluto's surface. It also proposes to send spectroscopy and temperature-mapping equipment and radiometry to gather information on the composition of the double planet.

The New Horizons mission is a breakthrough for the Pluto researchers, who were beginning to wonder if they would ever launch a spacecraft to the last planet. The work has had its first year funding approved and team members are confident funding will continue. (Although you might go to www.Astronomy.com to check on minute by minute changes from fickle budgeters.) For details on this mission and other Pluto prospects, check out physicist Andy Cheng's report "Pluto or Bust" on page 46.

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MEADE LXD55 6" 8" 10"

SCHMIDT-NEWTONIANS WITH AUTOSTAR®

Now you can buy a Meade Schmidt-Newtonian telescope with Autostar dual-axis GO TO drive system for as little as $599, *complete!*

Schmidt-Newtonian Optical Systems: Manufactured entirely at the Meade Irvine facility, LXD55 diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios, for brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser optical resolution.

LXD55 Equatorial Mount: Designed by Meade engineers and manufactured of machined aluminum for high-performance photo-visual observing, the new Meade LXD55 mounting moves effortlessly across the skies in either tracking or automatic GO TO modes. Included is an illuminated polar viewfinder for quick, precise polar alignment.

Autostar Dual-Axis Electronic Control System: A revelation of advanced electronic and software design, the exclusive patent-pending Meade Autostar system, included as standard equipment with every LXD55 telescope, permits an amazing range of capabilities never before offered on telescopes in this price and aperture class: *Automatic GO TO capability* at 4.5°/second on both axes simultaneously, to 30,223 database objects; *nine selectable slew and slow-motion speeds from* 1x sidereal to 4.5°/sec.; *automatic sidereal-rate tracking in R.A.* keeps objects precisely centered in the field.

Battery Pack (12vDC): Included with each LXD55 telescope; rests on the telescope's accessory shelf and plugs into the control panel. The battery pack accepts eight (user-supplied) D-cell batteries, which power the telescope for more than 40 hours.

SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens; standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

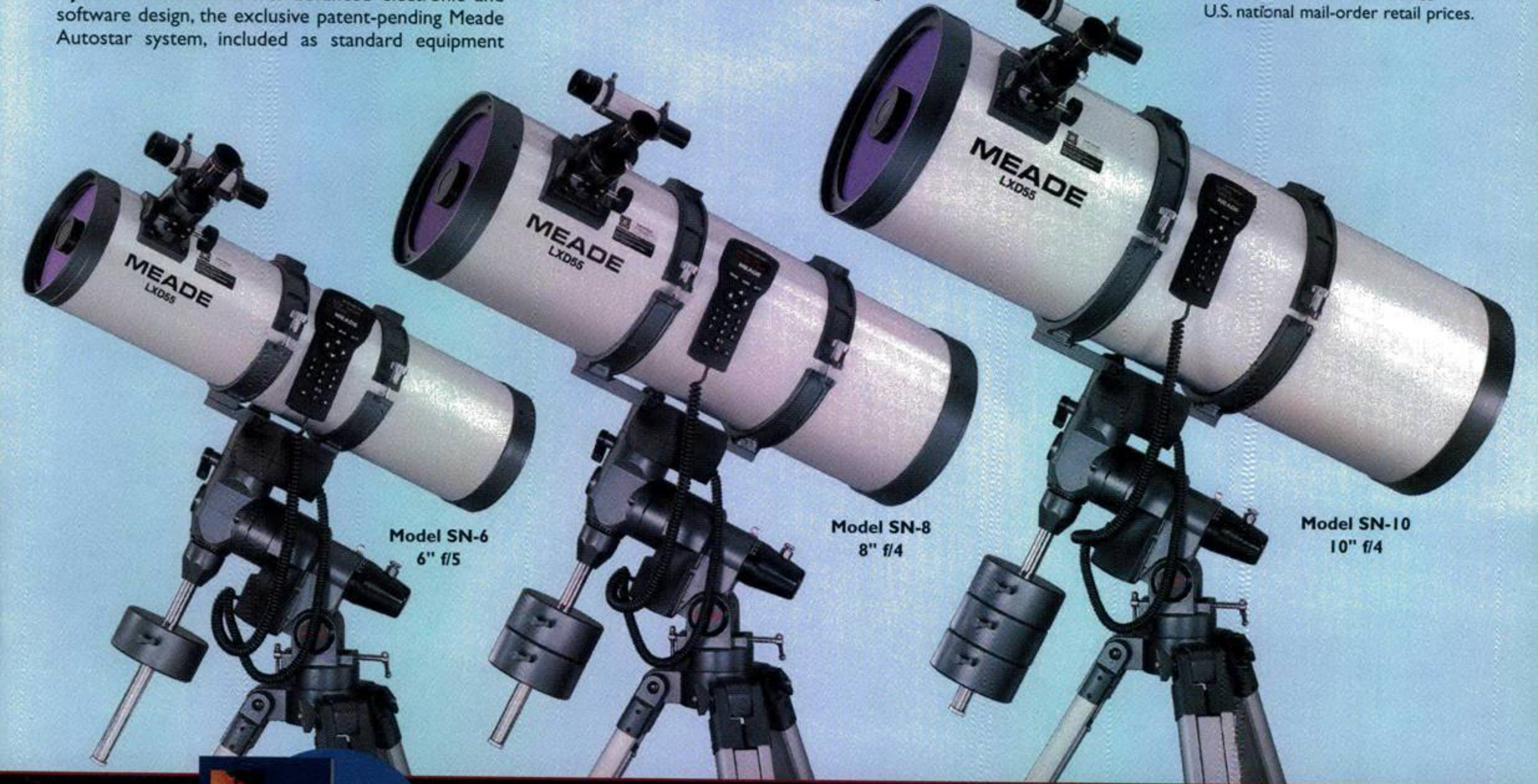
MEADE LXD55-SERIES SCHMIDT-NEWTONIAN TELESCOPES

Shipped complete per specifications above:

6" Model SN-6 Schmidt-Newtonian	**$599**
8" Model SN-8 Schmidt-Newtonian	**729**
10" Model SN-10 Schmidt-Newtonian	**879**

Ultra-High Transmission Coatings (UHTC) group *(see ad in this issue)*: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95. Prices shown are suggested U.S. national mail-order retail prices.



Model SN-6
6" f/5

Model SN-8
8" f/4

Model SN-10
10" f/4

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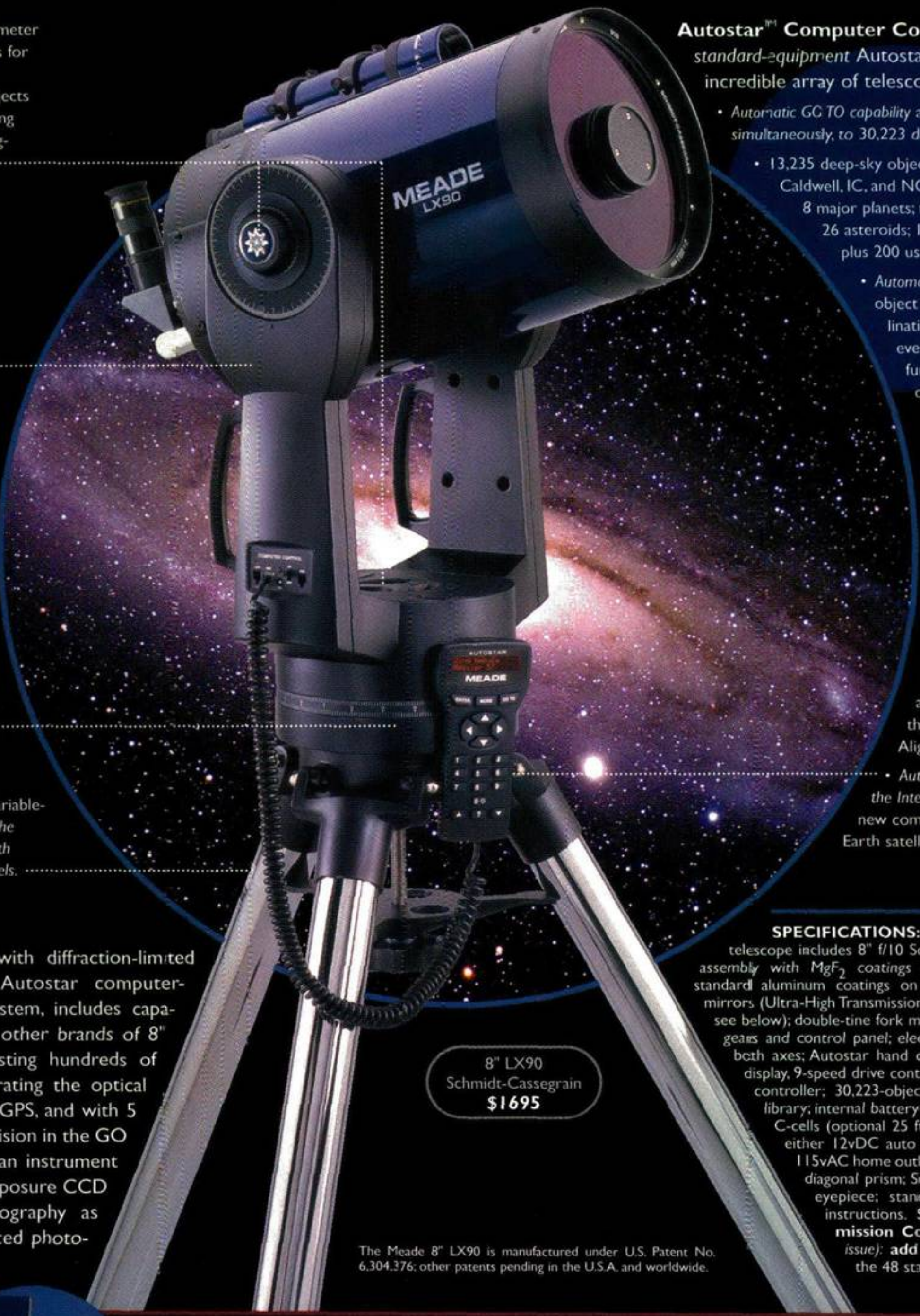
MEADE 8" LX90

LX90

THE TELESCOPE OF A LIFETIME



Worm gears of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in *all* sky orientations.

The LX90 is powered for 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an *automobile cigarette lighter plug* or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

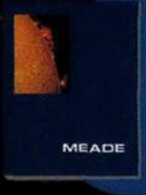
- *Automatic GO TO capability* at 6.5°/sec on both axes, *simultaneously, to 30,223 database objects, including:*
  - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability* to *any* object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- *Control of the telescope* through your personal computer. (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align.
- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

The Meade 8" LX90, with diffraction-limited Meade optics in an Autostar computer-controlled telescope system, includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is an instrument fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
$1695

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly *with MgF_2 coatings on the correcting lens and* standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; *electric slow-motion controls on* both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software *library;* internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super *Plössl* 26mm eyepiece; standard field tripod; operating instructions. **$1695. Ultra-High Transmission Coatings group** *(see ad in this issue):* **add $175.** Packing & shipping in the 48 states: $95.

The Meade 8" LX90 is manufactured under U.S. Patent No. 6,304,376; other patents pending in the U.S.A. and worldwide.



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Increase the image brightness and resolution of your Meade® telescope by 20% with the Meade® Ultra-High Transmission Coatings™ (UHTC) group.

Now you can increase the image brightness and resolution of your Meade ETX Maksutov-Cassegrain; LX10, LX90, or LX200GPS Schmidt-Cassegrain; or 6", 8", or 10" LXD55 Schmidt-Newtonian **by 20%** simply by specifying the Meade Ultra-High Transmission Coatings (UHTC) group with your telescope order.

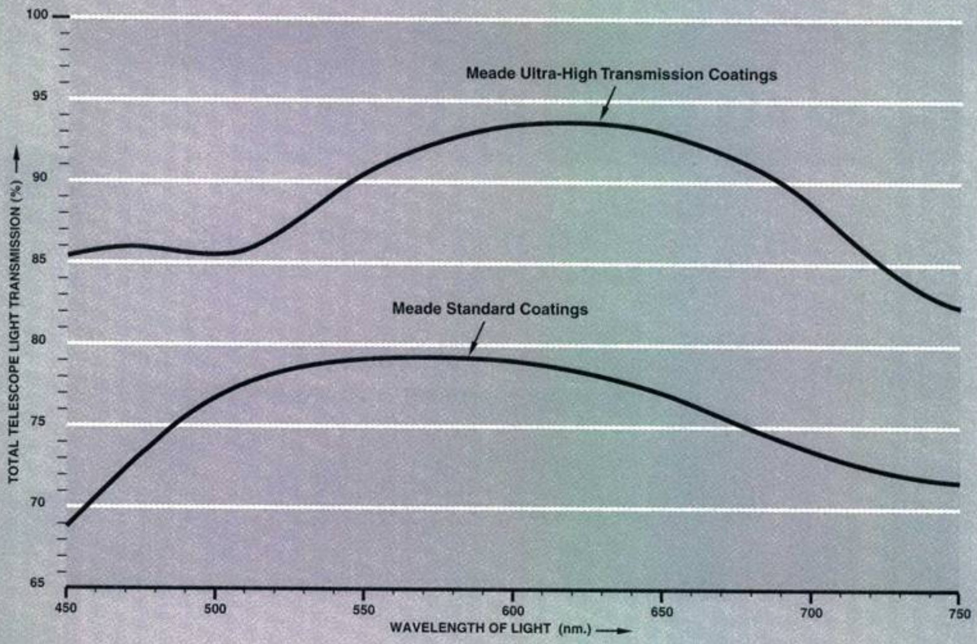
Meade Standard Coatings: Meade standard-equipment coatings include mirror surfaces of highly purified aluminum, vacuum-deposited at high temperature and overcoated with silicon monoxide (SiO), and correcting lenses coated on both sides for high light transmission with magnesium fluoride (MgF_2). *Meade standard mirror and lens coatings equal or exceed the reflectivity and transmission, respectively, of virtually any optical coatings currently offered in the commercial telescope industry.*

The Meade UHTC Group: Technologies recently developed at the Meade Irvine coatings facility, however, including installation of some of the largest and most advanced vacuum coating instrumentation currently available, have permitted the vacuum-deposition of a series of exotic optical coatings precisely tuned to optimize the visual, photographic, and CCD imaging performance of Meade telescopes.

In Meade mirror-lens telescopes, before incoming light is brought to a focus, it passes through, or is reflected by, four optical surfaces: the front surface of the correcting lens, the rear surface of the correcting lens, the primary mirror, and the secondary mirror. Each of these four surfaces results in some loss of light, with the level of loss being dependent on the chemistry of each surface's optical coatings and on the wavelength of light.

Mirror Coatings: Meade ETX, Schmidt-Cassegrain, and Schmidt-Newtonian telescopes equipped with the Ultra-High Transmission Coatings group include primary and secondary mirrors coated with aluminum enhanced with a complex stack of multi-layer coatings of titanium dioxide (TiO_2) and silicon dioxide (SiO_2), and with the thickness of each coating layer precisely controlled to within ±1% of optimal thickness. The result is a dramatic increase in mirror reflectivity across the entire visible spectrum; at the important hydrogen-alpha wavelength of 656nm. — the predominant wavelength of emission nebulae — reflectivity is increased from 89% to over 97%.

Control panel of a Meade UHTC electron-beam vacuum coater.


Meade Ultra-High Transmission Coatings
Meade Standard Coatings
TOTAL TELESCOPE LIGHT TRANSMISSION (%) ⟶
100
95
90
85
80
75
70
65
450
500
550
600
650
700
750
WAVELENGTH OF LIGHT (nm.) ⟶

Total telescope light transmission by wavelength of light. These graphs show the total amount of light transmitted to the telescope focus by the four optical surfaces (primary mirror, secondary mirror, and two lens surfaces) of Meade ETX, Schmidt-Cassegrain, and Schmidt-Newtonian telescopes. Meade standard coatings equal or exceed the total light transmission of virtually all other optical coatings currently offered in the commercial telescope industry; notwithstanding this fact, Meade UHTC coatings enable a dramatic increase in lunar, planetary, and deep-space image brightness and resolution. Note that the graphs presented here are spectrophotometric results of actual Meade mirrors and correcting lenses, not theoretical abstractions.

Correcting Lens Coatings: Meade telescopes ordered with the UHTC group include, in addition, an exotic and tightly-controlled series of coatings on both sides of the correcting lens or correcting plate, coatings which include multiple layers of aluminum oxide (Al_2O_3), titanium dioxide (TiO_2), and magnesium fluoride (MgF_2). Per-surface light transmission of the correcting lens is thereby increased at the yellow wavelength of 580nm., for example, to 99.8%, versus a per-surface transmission of 98.7% for the standard coating.

The importance of the UHTC group becomes apparent when comparing *total* telescope light transmission caused by the compounding effect of the four optical surfaces. With each optical surface contributing significantly to total telescope light transmission, the effect of all four surfaces *combined* is indeed dramatic, as demonstrated by the graphs above. At the H-alpha wavelength of 656nm., total transmission increases from 77% to 93%, an increase of 93/77, or 21%; at the oxygen-III wavelengths of 496nm. and 501nm. — important emission lines in diffuse and planetary nebulae — total transmission increases from 76% to 85%, an increase of 85/76, or 12%; at the helium wavelengths of 588nm. and 469nm. — strong emission lines in hot planetary nebulae — total telescope transmission increases by 18% and 19%, respectively. ***Averaged over the entire visible spectrum (450nm. to 700nm.), total light transmission to the telescope focus increases by about 20%.***

Observing with the UHTC: Meade telescopes equipped with UHTC present dramatically enhanced detail on all celestial objects — from emission and planetary nebulae such as M8, M20, and M57; to star clusters and galaxies such as M3, M13, and M101; to the Moon and planets. The overall effect of the UHTC is, as it relates to image brightness and resolution, to increase the telescope's effective aperture. **Image brightness and resolution (*i.e.,* the ability to image fine detail) of the Meade 10" LX200GPS are, for example, effectively increased by about one full inch of aperture.**

Pricing: *The Meade Ultra-High Transmission Coatings group, if desired, must be specified at the time of telescope purchase; the UHTC can not be retrofitted.* The UHTC is available for any of these Meade telescopes:

ETX-90EC–$50; ETX-105EC–$75; ETX-125EC–$95

8" LX10, 8" LX90, or 8" LX200GPS–$175;
10" LX200GPS–$235; 12" LX200GPS–$295

LXD55 Schmidt-Newtonians: 6" Model SN-6–$85;
8" Model SN-8–$125; 10" Model SN-10–$150

ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
The largest-selling telescopes in the world. ■ *A NASDAQ® company.*
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MEADE®

RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):
6.4, 9.7, 12.4, 15, 20, 26mm each: **$79.95** (4.54)
32mm (52°); **40mm** (44°) each: **99.95** (5.26)
56mm (52°; 2") **199.95** (7.02)

Series 4000™
Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A **49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A **49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56 **49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels.

$16.95 (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Series 4000™
2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm (far right in photo), an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm $79.95** (3.86)

#911B
#911N
#908B
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia. **79.95** (4.54)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)

#908N–Threads into 1.25" eyepieces, 26mm dia. **89.95** (4.54)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95** (5.26)

Series 4000 Oxygen-III Filters
Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)

#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **149.95** (5.26)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to less than one second. A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece

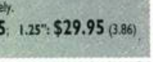
Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (5.26)

Camera Adapters



Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

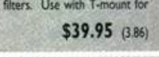
.965": $27.95; **1.25": $29.95** (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with **any** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces.
$149.95 (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces.
249.95 (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.)
15.00 (3.86)

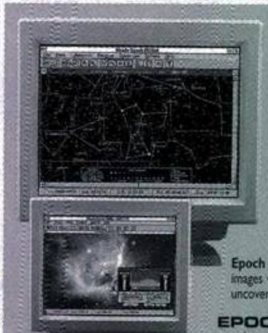
#644

#647

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate hand-box for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries.

$249.95 (9.85)



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left)*: Use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** Dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely! Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software: Enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP **$99**

LX200 Interface Cable: for Meade LX200/LX200GPS operation by Epoch 2000sk. **25**

EPOCH 2000ip **Image Processing Software:** On CD-ROM for Windows 95, 98, 2000, NT, and XP **99**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#875 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

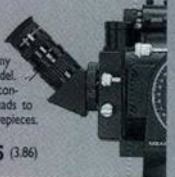
$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

$34.95 (3.86)

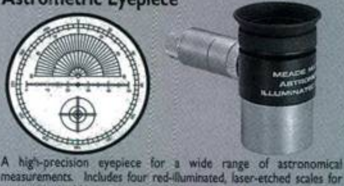
#932 45° Erecting Prism for ETX®



For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

$49.95 (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25".

$119.95 (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25".

$219.95 (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models:
99.95 (8.58)

#776 Case for ETX-105EC:
99.95 (8.58)

#775 for ETX-125EC:
149.95 (13.38)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70	**19.95**
#673 for ETX-90	**24.95**
#675 for ETX-105	**27.95**
#678 for ETX-125	**29.95**

Pictor 216XT CCD Autoguider/Imager

The most advanced Autoguider/Imager in its price class. For many, all the CCD imager required for a wide range of lunar, planetary, or deep-space applications. Includes the same "point-and-shoot" simplicity of larger Pictor models. Produces smooth, natural 16-bit images of all celestial subjects. Also a precision autoguider during astrophotography.

$695. (12.00)

Advanced Field Tripod for ETX-125

#887: Yields *rock-solid* stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

#889 Adapter: Available separately, permits attachment of ETX-125 to any Meade LX10 or LX200 Field Tripod or wedge. **$69.95** (7.70)

ETX® Deluxe Field Tripod

#884: Constructed of strong, lightweight steel; designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 25" to 43", for seated or standing observations. Graduated scale for elevation angle from 20° to 90° permits precise polar alignment of the telescope for astronomical applications. Tripod tilts and locks at 90° for terrestrial applications or for altazimuth use with Autostar. Telescope attaches to tripod in seconds with 2 thumbscrews. **Includes custom-fitted carry bag *(shown)* with pocket for accessories.**

$199.95 (10.00)

ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories.

$36.95 (5.26)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models:
$119.95 (6.85)

#1247 Electric Focuser for ETX-125 models:
$119.95 (6.85)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

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EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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MEADE

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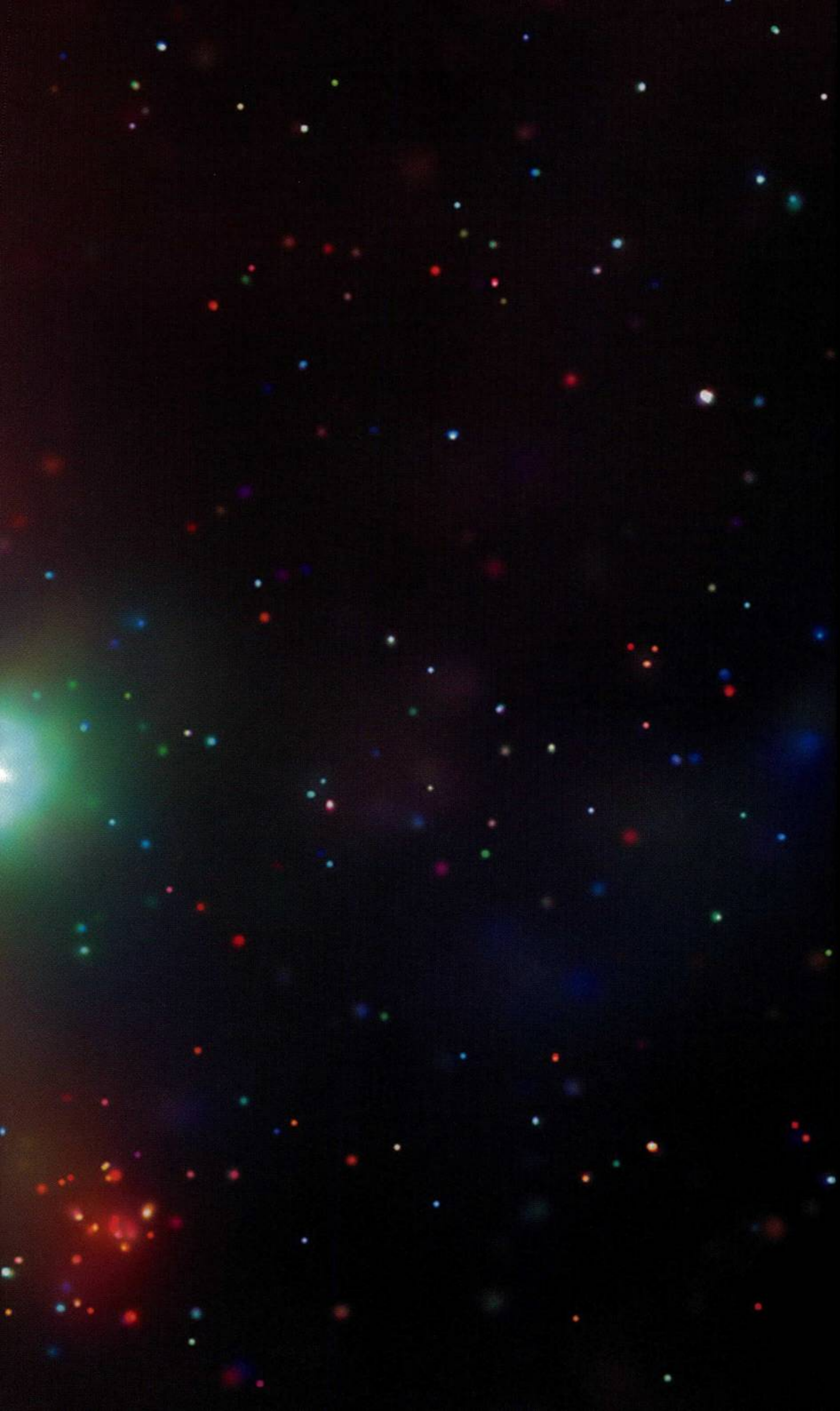

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Are Go-to Scopes a Go?

The article "To Go-to or Not to Go-to" (February 2002) missed several key issues. First, a manual telescope holds more "bang for the buck;" for example, you can get an 8-inch Dobsonian for the same price as a Go-to 70mm refractor. Larger aperture equals more objects and greater detail.

Also, many telescopes can be computerized with easily installed kits. The difference between this and Go-to telescopes is that the observer supplies the horsepower, and if the computer or battery gives out, the user can revert to star-hopping. If almost anything breaks down on a Go-to scope, the night is lost. Most computers for non Go-to scopes are relatively simple to operate, causing less frustration. — *Geary Keilman, Las Vegas, Nevada*

I believe it is a mistaken assumption that a Go-to scope alleviates the need to learn the night sky. Beginners will still need to use books or star charts to decide what to look at; they simply don't learn to star-hop. While some will still not learn the sky, these people would also never take the time to learn enough to use a traditional scope.

Also, entry-level Go-to scopes cost about the same as traditional scopes, especially if you add the cost of a clock drive. While you can buy substantially larger Dobsonians for the same cost, they are aimed at experienced observers; they require much more experience to find anything other than the easiest objects.

Go-to scopes have resulted in a widespread awareness in the wonders of astronomy like we have never seen before. We need to embrace this expansion of technology and guide beginners in appropriate ways. — *Mike Swanson, Okinawa, Japan*

While Earth spans four moon diameters, the moon holds 50 times less volume. Anthony Galvan III

I am fully in support of Go-to technology. Any beginning astronomer will find it easier to observe without having to laboriously search for objects. Then, if they want to learn more, they will begin to learn the sky. While not everyone will want to take the time to learn, many will. Go-to scopes have made it possible for people who otherwise never would have touched a telescope to observe the sky and discover what's out there. — *Connie Lavelle, Yonkers, New York*

The debate over Go-to telescopes reminds me of my college physics professor, who once proclaimed, "You cannot learn physics using a calculator, you must first master the slide rule." In other words, the Go-to feature is merely a tool to help beginners. It has not only inspired me to read several sky-watching books, but also to subscribe to *Astronomy*. — *Walter N. Prendergast, Reno, Nevada*

Sizing the moon

In "Beginner's Sky" (February 2002), Jerry Burstein states that Earth is four times the size of the moon. I found this confusing, as I did not realize at first that he was referring to diameter. Earth's area is about 15 times that of the moon, while the volume is 50 times more. Perhaps all answers should have been given with explanations. — *Tom Reesor, Conway, South Carolina*

Calling all astronomy buffs

Chaco Culture National Historical Park, a World Heritage Site and center of Ancestral Pueblo culture, is seeking volunteer amateur astronomers to assist with public programs at its observatory during the 2002 and 2003 spring, summer and fall seasons. Volunteers at the park, located at an elevation of 6,000 feet near Nageezi, New Mexico, operate a fully equipped observatory with five astronomical telescopes (up to 25 inches in aperture) and a complete CCD imaging system with adaptive optics. Volunteers present night sky and solar-viewing programs to park visitors in exchange for free park admission and access to the observatory for personal use. The volunteers managed more than 14,000 visitor contacts during 2001.

Volunteers are asked to make a substantial time commitment to the programs, averaging 20 hours per week for a six-week period between April 1 and November 1. They must provide their own recreational vehicle, and will then be given free use of the park's "VIP" camping facility, including full hook-up, hot water showers, and a

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For more information, contact Tommy and Linda Taylor at ttaylor@speedrulz.com or 978-263-0904. — *Tommy Taylor, Volunteer Coordinator, Acton, Massachusetts*

Travel trip-ups

"Spaced-out Travel" (March 2002) by Kelly Kizer Whitt listed some incorrect information. The Reuben H. Fleet Science Center was called the Reuben H. Fleet Space Theater and Science Center, along with the San Diego Aerospace Museum. The two museums appeared as though they are the same, but they are separate entities. The Aerospace Museum showcases accomplishments in air and space travel through the decades. Additionally, the Science Center's Meteor Storm is not an exhibit, but a virtual reality experience. The address of the Aerospace Museum is 2001 Pan American Plaza, Balboa Park, San Diego, California. The zip code for both is 92101. —*Cindy Pittman, Reuben H. Fleet Science Center, San Diego, California*

"Spaced-out Travel" indicates that the Griffith Observatory in Los Angeles is in operation. But the observatory is currently closed for renovation and expansion, and will not reopen for at least three years. — *Robert C. Klesges, La Crescenta, California*

Thank you for including Boston's Hayden Planetarium in "Spaced-out Travel." We noticed one small correction: We do not bring in "live images from space transmitted to the planetarium dome" during shows. We do, however, bring much enthusiasm from our staff along with a great view of the stars, thanks to our star projector. — *Noreen Grice, Charles Hayden Planetarium, Boston, Massachusetts* A

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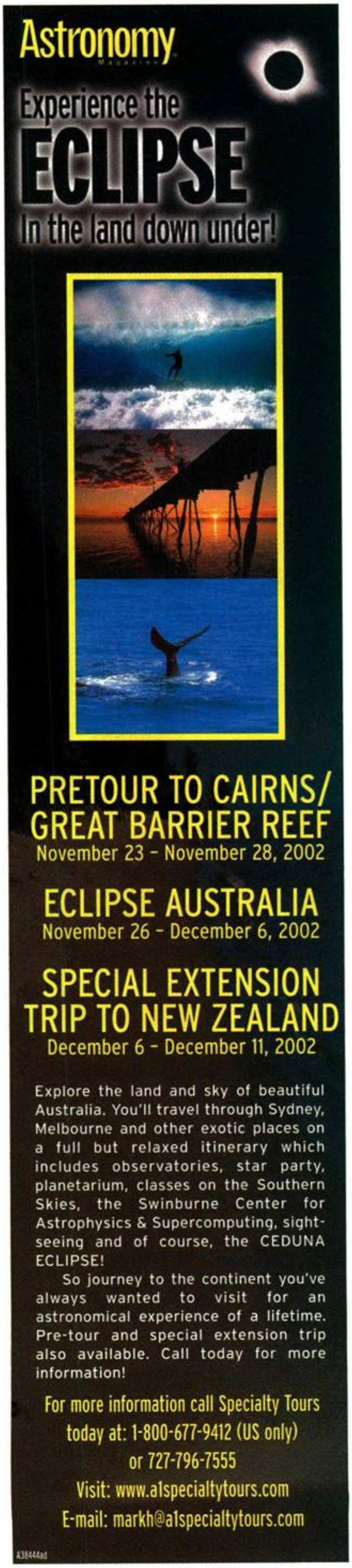
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The Stellarvue refractor, "Hot New Product of 2001."

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AT1010CN $499^{95}
shown w/optional diagonal and eyepiece

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Meade 8" LX90
$1695

We generally keep several dozen of the LX90 in stock (it's one of our best-selling scopes), so chances are good you can get *your* LX90 with little or no delay. If Meade is shipping the LX90 *(or any Meade scope)* for a dealer to keep in stock, the chances are very good that we *have* it in stock.

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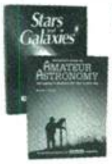

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The NexStar 11" got a great review. You can have your 11 in a week.

Celestron's 11" go-to computerized scope – the **NexStar 11 GPS** – got a *rave* review in February's *Sky & Telescope.* The review gave it "an enthusiastic two thumbs up and a gold star." They said it has "Brains and good looks. The NexStar 11 GPS puts Celestron's time-tested 11-inch f/10 Schmidt-Cassegrain optics in a sleek new package that includes some of the most advanced electronics ever offered in a mass-produced telescope . . . Celestron is the first to take Go To scopes to the next step in their evolution, and it's a nice step indeed."

We have the NexStar 11 in stock (23 as this was written). Call us and you can be observing with yours within about a week.

NexStar 11 GPS
$2999

A $100 rebate and a free Ultima Barlow with the NexStar 8 GPS!

NexStar 8 GPS **$2499**

The in-stock **NexStar 8 GPS** 8" – like the NexStar 11 – has Fastar optics for CCD imaging. The 8 GPS can convert to an ultra-fast f/1.9 focal ratio for wide field images. With an optional Fastar lens assembly and a $1295 SBIG ST-237A CCD camera, the 8" GPS will record a huge 32 x 42 arc minute field – bigger than the Moon and over three times the area of a $7695 camera on the same scope without Fastar! *Only Celestron has Fastar optics!*

Buy a NexStar 8 GPS before April 15, and Celestron will send you a $100 check, plus a $120 list Ultima Barlow. Double the power and $100 cash back! That's a real deal indeed!

Compare Celestron go-to prices. Only $1499 for an 8" . . .

NexStar 8
$1499

Compare the price of the **Celestron NexStar 8** go-to SCT with other 8" go-to scopes. At only $1499 – complete with adjustable height tripod, Starbright multicoated optics, red dot finder, 40mm Plössl eyepiece, and a computer with 18,000+ objects in its memory – it's priced hundreds of dollars less than other 8" go-tos. It's enough telescope to keep you busy observing for the rest of your life, at a price that puts 8" go-to astronomy within the reach of practically everyone!

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$1149 for a 5" . . .

NexStar 5
$1149

You get a $149 value adjustable height aluminum tripod (with built-in equatorial wedge) and a computer control *for free* when you buy a **Celestron NexStar 5** go-to Schmidt-Cassegrain. Compare the price with the price of other 5" go-to scopes (including a tripod and computer) and you'll see that Celestron saves you nearly $50. NASA uses 5" Celestron optics on the Space Shuttle. Don't you deserve the same premium image quality?

$599 for a 4" . . .

The 4000-object computer of the **Celestron NexStar 4** go-to Maksutov is standard equipment, not an option as it is with some scopes. The computer's hand control can be used even when docked conveniently in the scope's sleek single fork arm mount. A red dot finder makes aligning on the skies a snap. The AA battery-operated tabletop NexStar 4 is so easy to use that you'll be observing only minutes after you take it out of the box. At only $599, *complete,* it's almost $200 less than competitive 4" go-to Maksutovs.

NexStar 4
$599

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A $450 binocular for only $\$179^{95}$!

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Discovery Dobsonian reflectors start at only $299.

6" f/8 DHQ, shown with optional eyepiece rack
$299

Why settle for an imported Dob when you can have made-in-the-USA quality *for less money!* Discovery doesn't use imported, mass-produced optics that are merely spot-checked to see if they're acceptable. Discovery optics are made in California by optical craftsmen, one quality mirror at a time. Each is hand figured to diffraction-limited performance, and it doesn't leave the Discovery optical shop until it's right.

Each DHQ series Dob has an adjustable metal primary mirror cell, a true *thin vane* adjustable 4-vane diagonal mirror spider, *two* Plössl eyepieces, a built-in tube balancing system, a tube carry handle, new oversized bearings, a 6 x 30mm finder, and a dust cover. You can get an upgrade kit that adds two more Plössl eyepieces, an eyepiece rack, a second dust cover, and a Moon filter for only $49 more!

Premium Dobs from 10" to 17.5" in aperture are also available. And for those who need big aperture portability, truss-tube Dobs are available in apertures from 12" to 24". Here are the Discovery 6" to 10" DHQ Dob prices:

6" f/5 Discovery DHQ	$\$299^{00}$	plus $49 freight
6" f/8 Discovery DHQ	$\$299^{00}$	plus $49 freight
8" f/6 Discovery DHQ	$\$399^{00}$	plus $49 freight
8" f/7 Discovery DHQ	$\$399^{00}$	plus $49 freight
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10" f/5.6 Discovery DHQ	$\$599^{00}$	plus $69 freight

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2DF SURVEY

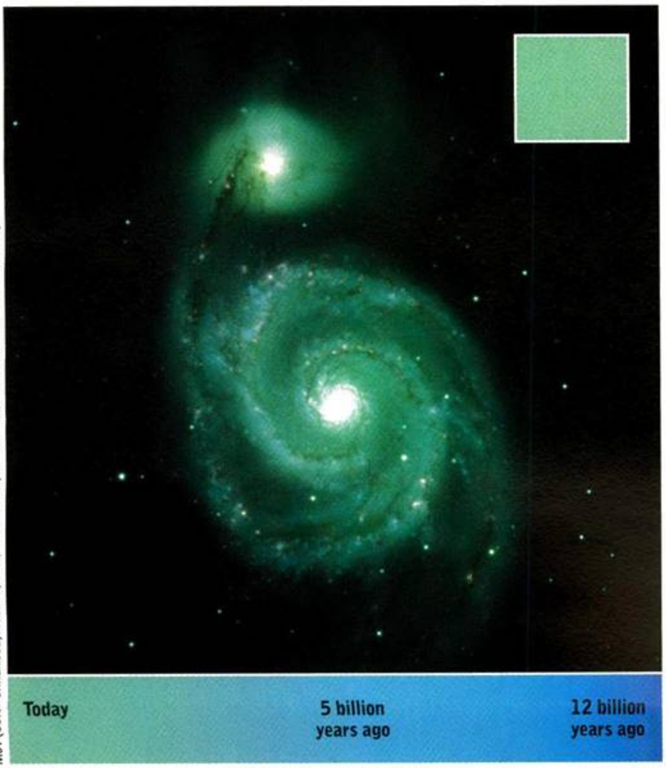
What Color Is Your Universe?

▶ It took a huge, multi-year sky survey, involving redshift measurements for roughly 250,000 galaxies, but astronomers now think they know the color of the universe: a pale shade of green, lying somewhere between medium aquamarine and turquoise. At least that's the way it would appear if light from nearby stars and galaxies were magically combined.

The findings, by Johns Hopkins University astronomers Karl Glazebrook and Ivan Baldry, are an offshoot of analyses they conducted with colleagues on the Two Degree Field (2dF) Galaxy Redshift Survey — the largest spectroscopic survey completed to date. But figuring out the color of the universe was by no means the main purpose of this endeavor. In fact, the idea had not even been considered when 2dF was conceived. Key questions addressed by the survey include computing the mass density of the universe, studying the evolution of structure, and tracing the history of star formation. The latter task revolved around a calculation of the "cosmic spectrum" — a graph of the intensity of light collectively emitted by galaxies at various wavelengths across the visible band. With the cosmic spectrum in hand, 2dF astronomers were able to determine that the majority of stars in the universe formed more than five billion years ago.

On a lark, Glazebrook suggested taking the cosmic spectrum and — drawing on techniques from optics and ophthalmology — converting it into the average color perceived by humans. The greenish hue they settled on is the color that would be seen today. The universe's color, Glazebrook and Baldry note, changes over time: The galactic glow was considerably bluer six billion years ago (when stars were younger and bluer) than the current pale green, and it will become redder as the stellar population ages.

But how can they be sure of the color of the entire universe after inspecting just five percent of the sky? Baldry is confident because he and his colleagues divided their survey volume (which spans roughly 13 billion, billion, billion cubic light-years) into 10 different regions, and the cosmic spectrum was virtually identical in each. "If we looked in 10 different directions and the average spectrum of galaxies was substantially different, we'd know our survey didn't cover a large enough volume," he says. "The fact that they all look similar means our sample is representative of the universe." To verify those results, he and Glazebrook also drew on data collected by the Sloan Digital Sky Survey and arrived at the same average spectrum and color. — Steve Nadis



Color crazy: Today, the collective light of the local universe casts a cosmic green hue (inset). Twelve billion years ago it was blue.

M51 (color enhanced): NOAO/NSF/T. A. Rector/M. Ramirez, Inset and timeline: *Astronomy*

HOBBY NEWS

Amateurs Score Space Telescope

▶ From Atlanta to Zurich, amateur astronomers are abuzz with excitement over what the future holds for their hobby. After all, it's literally about to launch into space.

It's been nearly two years since the Astronomical League announced plans to launch the world's first amateur space telescope to fly aboard the International Space Station (ISS) by the close of the decade.

Meanwhile, hungry hobbyists have been eagerly awaiting the opportunity to score crisp images of their favorite deep-sky objects. And now, the reality of a first-class space telescope for the world has taken a giant leap forward as the ISS Amateur Telescope (ISS–AT) prototype went online February 2.

Much like its soon-to-be-finished 16-inch (40-cm) cousin designed to float freely above the main support truss of the ISS (to avoid station vibrations), the ISS–AT prototype (called the Alpha Telescope) is a 12-inch (30-cm) Cassegrain reflector.

Presently, engineers are testing the Alpha Telescope at Winer Observatory, located near Sonoita, Arizona. In addition, project leaders are also putting into place the procedures that will make the telescope

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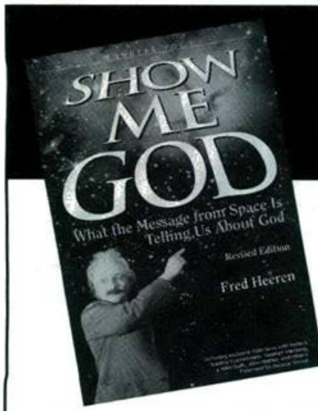

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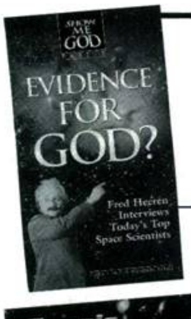

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NASA

The Astronomical League vows to attach an all-access amateur space telescope to the International Space Station by 2010.

available to anyone with an interest in astronomy and access to the Internet.

The novel endeavor to afford amateurs with access to a space telescope of their own, is spearheaded by the Astronomical League, a consortium of more than 240 American astronomy societies based in Kansas City, Missouri.

In keeping with their primary objective to promote the science of astronomy worldwide, the Astronomical League is teaming up with experts from first-rate government programs such as NASA's Telescopes in Education program. In addition, the league has struck collaborations with technology industry giants like the Dell Computer Corporation and The Boeing Company, which will furnish the ISS–AT's computing support structure and guidance systems, respectively.

If you are interested in submitting your own observing proposal, tracking the ISS-AT's progress, or gaining access to archived public data, visit the ISS-AT homepage at www.issat.org. — W. B. Schomaker

LUNAR SCIENCE

Measuring-up to the Moon

▶ One astronomer is giving new meaning to the expression "shoot for the moon," and in so doing just might get the most precise measurement ever of the Earth-moon distance.

In a technique known as laser ranging, University of Washington postdoctoral scholar Tom Murphy plans to shoot "bullets" of laser light up at suitcase-size mirrors, or "retroflectors," on the lunar surface, left behind by past lunar missions. These prismatic retroflectors bounce light back to its source — in this case, the 11.5-foot (3.5-meter) telescope at Apache Point, New Mexico.

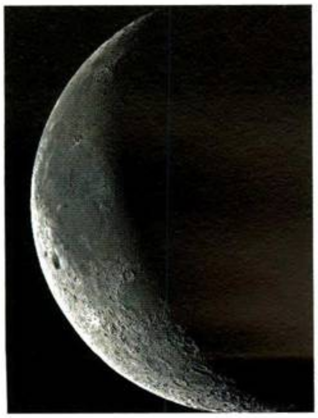
Murphy will use a powerful (1 billion watt) laser to generate a 1-inch (2.5-cm) pulse of light aimed through the large telescope at these lunar-based retroflectors. He will calculate the distance by measuring the light bullet's round-trip travel time, multiplying that figure by the speed of light, then dividing it in half.

He hopes to nail down the Earth-moon distance — formerly measured in the mid-1980s at 238,700 miles (384,150 km) ± 2 centimeters (less than an inch) — to within a millimeter, or roughly the thickness of a paper clip.

This ever-so-exacting measurement will then allow researchers to perform ultra-sensitive tests on several aspects of gravity, one of which may determine whether the force of gravity is being diluted as the universe expands.

"We don't know enough about gravity, so we have to probe gravity with every tool we have available," says Murphy. — Paul Morledge

In the quest to understand gravity, astronomers are measuring the distance to the moon — to the nearest millimeter. ESO



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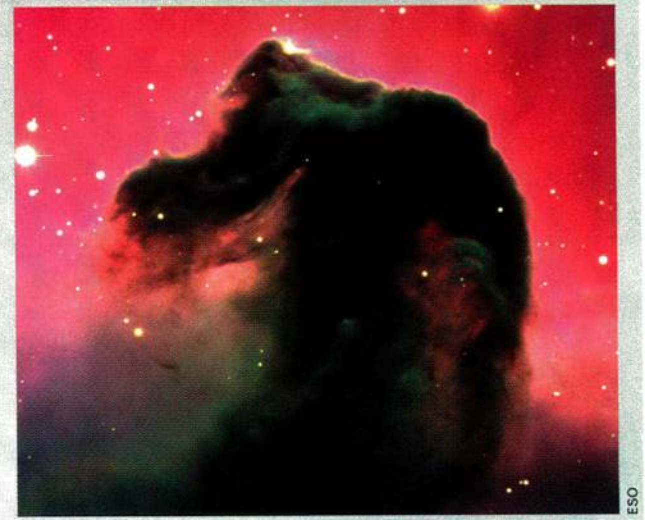

ESO

SURROUNDED BY CELESTIAL PASTURES of the Orion molecular cloud complex, the famous Horsehead Nebula (Barnard 33) holds up under scrutiny from one of astronomy's biggest eyes. The European Southern Observatory's 27-foot (8.2-meter) VLT Kueyen telescope captured this high-resolution image of the Horsehead from its perch in the Chilean Andes. Deep red hues correspond to light from hydrogen, while browns and blue-greens are generated by foreground dust and scattered starlight, respectively. New views of the nebula, which lies approximately 1,500 light-years from Earth, show it to be a bustling site of activity, from new star formation near the bottom of this image, to the blistering effects of photo-ionization of interstellar gas, near the crown of the Horsehead.

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ASTROCHEMISTRY

Space May Not Be So Wet

New findings suggest that water may not play a prominent role in planetary system formation.

▶ Thanks to data from the European Space Agency's Infrared Space Observatory (ISO), astronomers are being forced to rethink their ideas about the abundance of water in the universe as well as the history of the solar system.

If you subscribe to the long-standing party line of planetary scientists, carbonates — rocks and minerals containing carbon and oxygen, such as limestone and dolomite — require liquid water to form. What's more, liquid water is mostly found on or within large planetary bodies.

Therefore, to explain the presence of very old carbonates, water-logged planetary bodies must have formed very early and often in our solar system and similar star systems across the galaxy.

But according to the January 17 *Nature* report from an international team of astronomers, this may not be the case. The team recently discovered large concentrations of carbonates from ISO observations centered on two dying stars — both very far from large planetary bodies and any existing reserves of water. Now the surprising results are causing scientists to consider the possibility that carbonates may form without water after all.

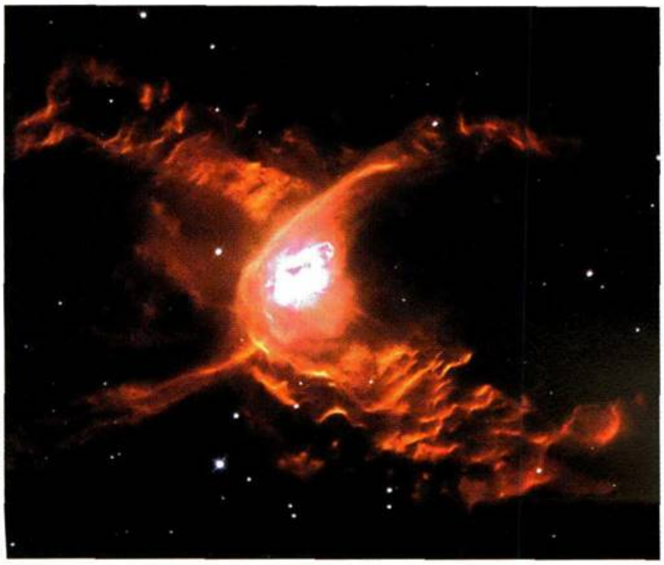
The team analyzed data from both the Bug Nebula (NGC 6302) and the Red Spider Nebula (NGC 6537). These two planetary nebulae have been expelling material through dense stellar winds for the past 10,000 years, forming a shell around the central stars. And deep within these nebular shells, ISO uncovered the telltale chemical signatures (or spectra) of carbonates.

"The amount of carbonates we find is equivalent to at least 30 Earth masses, far too large to be the relic of a hypothetical planetary system present before the star became a planetary nebula. On the other hand, the age of the dust-shell in [the nebulae] is about ten thousand years, which is too short for a new planetary system to form," explains Ciska Kemper of the University of Amsterdam.

Therefore, the team has concluded that the carbonates could not have formed via large-body-assisted aqueous processes.

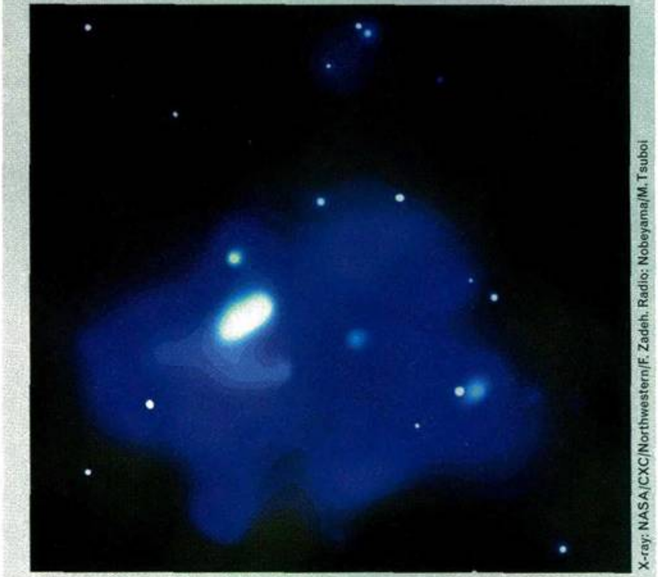
While the scientists are certain that these newly discovered carbonates formed through some alternative method, as yet unknown, they remain unsure about the degree to which their ideas about the solar system's formation will be affected.

"The point is that it might be easier to form carbonates than people have previously thought; it is not necessary to first form planet-like bodies," says Kemper. "Carbonates could be present before the first planets were present. They could be formed *in situ*, but it might even be true that they originated from evolved stars and have survived their residence in the interstellar medium." — Elesa Janke



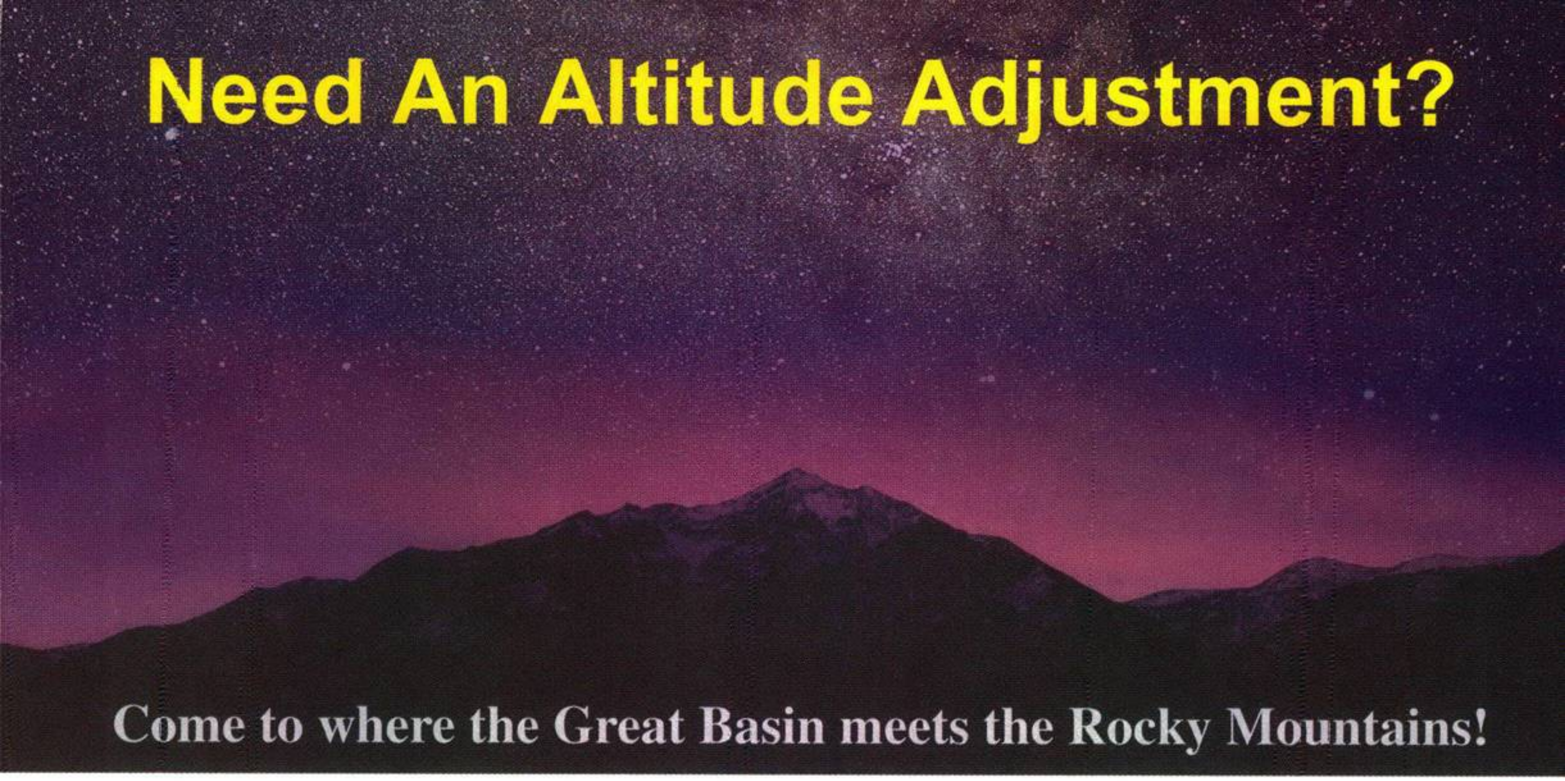
NGC 6537: NASA/ESA/HST

CHANDRA X-RAY OBSERVATORY



X-ray: NASA/CXC/Northwestern/F. Zadeh. Radio: Nobeyama/M. Tsuboi

DEEP WITHIN THE HEART OF THE GALAXY lies a peculiar multi-wavelength monster. Brilliant across the spectrum, from radio waves to x rays, a 40 light-year-wide ridgelike filament has kept astronomers guessing about its origin for nearly three decades. With recent Chandra X-ray Observatory images of the Milky Way Galaxy's center, astronomers now believe that the bulk of the x-ray emission from this mysterious filament is generated by electrons slamming into gigantic clouds of cold gas — one million times more massive than the sun. The blue hues of this composite image are generated by x-ray emission, while the green hues originate from radio waves emitted by tons of cold gas.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SOLAR NEIGHBORHOOD

New Neighbors for the Sun

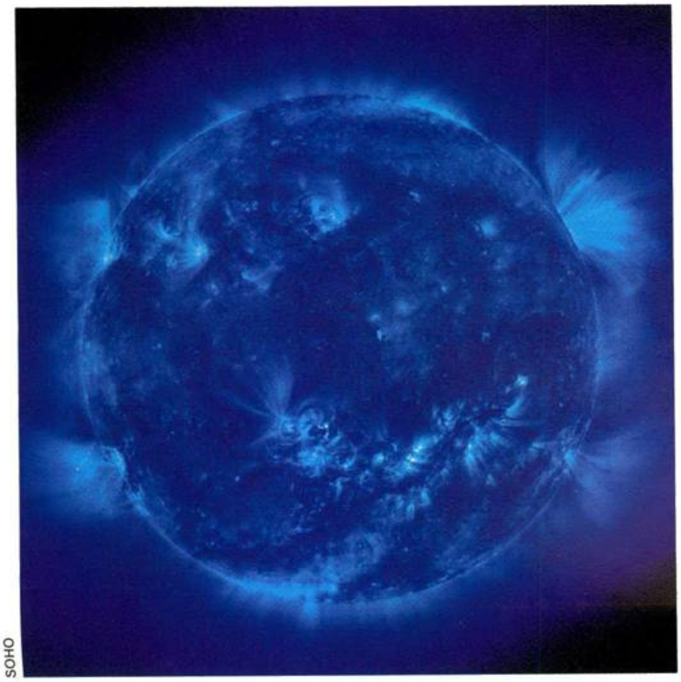
▶ With the recent proliferation of 8- and 10-meter telescopes, you might think that the small telescopes of the world would be put out to pasture.

But while the behemoths of the astronomical world are searching out faint targets in the distant universe, many smaller telescopes pay their keep by scouring nearby space for equally elusive objects.

An international team of astronomers led by Todd Henry of Georgia State University has shown just how valuable this effort can be, and in the process underscored how little astronomers know even about our sun's neighborhood. The team, which includes researchers from Georgia, Virginia, and Chile, announced the discovery of 12 new stars lurking within 10 parsecs (32.6 light-years) of the sun at this year's meeting of the American Astronomical Society in Washington, D.C.

Henry likens the search for such nearby stars to a treasure hunt, with each new find a gem. "Each of the new stars provides a fresh target where we can look for planets and, ultimately, for life on those planets," he says.

Using the 36-inch (0.9-meter) and 60-inch (1.5-meter) telescopes at Cerro Tololo Interamerican Observatory, located 50 miles east of La Serena, Chile, the researchers observed more than 200 star systems in the southern sky. This area proves to be a fertile hunting ground for such widespread searches because, historically, most observations of nearby stars took place from the Northern Hemisphere.



SOHO

Thanks to a new southern-sky survey, our corner of the galaxy isn't quite so lonely. Astronomers recently found 12 new stars within 33 light-years of the sun.

The team measured how much the stars moved relative to the background stars. These tiny motions reflect both the movement of the star through the galaxy and our changing vantage point as Earth orbits the sun. (The shift in a star's position when viewed from different points along Earth's orbit is analogous to your finger's change in position relative to distant objects when you blink one eye and then the other.) Simple geometry then allows one to calculate the star's distance.

The 12 new stars belong to nine separate systems: seven single stars, one double-star system, and one triple system. This increases the number of known stars within 10 parsecs to 316 inhabiting 228 systems. All the new ones glow hundreds or thousands of times fainter than the naked eye can see — the reason they eluded detection until now.

Eleven of the new stars are cool red dwarfs, while the 12th is a white dwarf. Most stars in the universe are red dwarfs, including the closest star to the sun: Proxima Centauri.

Still, Henry thinks there could be a star closer than Proxima and — if there is — he hopes to be the one to find it. — Richard Talcott

JODRELL BANK OBSERVATORY

JBO

SOON TO BE BETTER THAN NEW, the 250-foot (76-meter) Lovell Radio Telescope at the Jodrell Bank Observatory, 20 miles south of Manchester, England, is in the midst of a major facelift. Though the interim process has left the immense radio dish — a pioneer in the search for radio pulsars, gravitational lenses, and extraterrestrial intelligence — looking a little worse for the wear with its rusted steel sectors exposed, the makeover promises to render the 45-year-old dish 30 times more sensitive than at the time of its 1957 debut. By the close of this summer, the third largest fully steerable radio telescope in the world will once again be ready to impress astronomers, at one-tenth the price it would have cost to build a new telescope.

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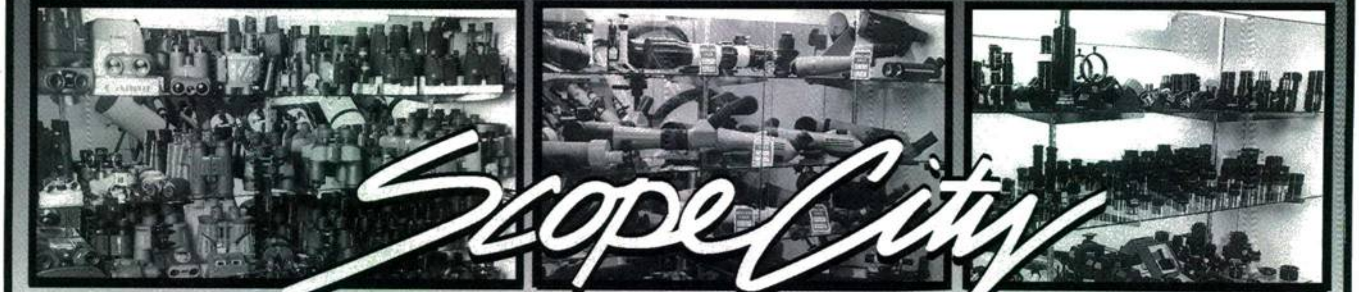

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PLANETARY SCIENCE

Cryobot Gets Ready for Space

▶ Thousands of miles from the relative comfort of the Jet Propulsion Laboratory offices in Pasadena, California, JPL engineer Lloyd French and his team recently braved bone-chilling temperatures and threats from migrating polar bears to cheer on their smallest, yet most important, team member. In addition to engineers with NASA, JPL, and the Norwegian Space Center, French's collaboration is spearheaded by an ice-drilling cryobot who's leading the way for future, life-sniffing explorations beneath the icy surfaces of Mars and Europa.

"In exploring planets, we've observed from two environments: space orbits and planet surfaces," says French. "Now we have a potential third — subsurface."

The operating principles behind French's cylindrical cryobot, measuring 3.3 feet (one meter) long by 5 inches (12 cm) across, are quite simple. Heated water in the nose of the cryobot melts the ice in front, allowing gravity to drive the probe deeper.

Earlier this year on the Longyearbreen glacier, far above the Arctic Circle in Spitsbergen, Norway, the JPL cryobot dug to a record depth of 75 feet (23 meters) below the Arctic ice. In addition to using less power than traditional auger drilling probes, the cryobot enjoys increased mobility while posing less of a contamination threat, since it doesn't expel caustic antifreeze to keep the bore hole open. In fact, as the bot descends, ice behind is allowed to refreeze.

The JPL probe carries onboard cameras and detectors in addition to tethered communication, navigation, and descent-control systems. "There's never been a probe before that does what this one can," says Wayne Zimmerman, lead engineer for the project. In addition to scheduled trips to Mars in 2007 and Europa in 2008, cryobots may come in useful for studying microbes living beneath the Antarctic ice, in any of the dozens of ice-locked lakes there. — W. B. S.

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JPL

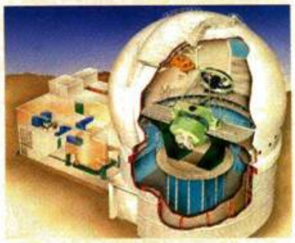
JPL's sleek cryobot could be first to encounter extraterrestrials.

Berkeley Team Breaks Supernova Best

For four years, a team of superbomb sleuths, led by University of California–Berkeley astronomer Alex Filippenko, has scanned the skies for Type Ia supernovae, which purportedly can shed light on the fate of the universe. And with the 30-inch (76-cm) Katzman Automatic Imaging Telescope (KAIT) at the Lick Observatory, the team keeps getting better and better with on-the-job experience. In 1998, Filippenko and his colleagues discovered 20 new supernovae — not bad for the first year out. But following a leveling trend from 40 new supernovae in 1999 to 36 in 2000, the team is pleased to report that it netted 68 new supernovae in 2001 — more than two-thirds of the total from the previous three years. All told, KAIT has discovered roughly 175 distant supernovae since the telescope went on line. In the meantime, KAIT data is being employed to confirm whether the expansion of the universe is accelerating.

New Camera Shows Promise

According to scientists at the European Space Agency (ESA) a revolutionary new camera (called S-CAM) will soon change the face of astronomical observing. The culmination of a decade-long project, S-CAM (short for superconducting camera) is poised to replace the standard Charge Coupled Devices (CCDs) that astronomers use today. CCDs can only measure the brightness of incoming light from celestial objects. Because the superconductor at the core of S-Cam is a perfect conductor at low temperatures, not only can the brightness of light be measured, but the arrival time and color of each photon can also be recorded. With new detectors like S-CAM, astronomers will finally be able to study complex, real-time phenomena, such as cataclysmic variable stars and visible pulsar emissions.



ESA

The S-CAM is being tested at the William Herschel Telescope.

NASA to Test Mini Spacecraft Armada

Space Technology 5 (ST5) forms the fifth leg of NASA's New Millennium Program aimed at developing future spaceflight technologies. Fueled by the need to reduce costs — $6,000 will currently purchase one pound of payload a trip into low-Earth orbit — America's space agency is looking for ways to greatly reduce payload weight, without sacrificing scientific gain. In 2003, three ST5 nanosatellites, weighing less than 50 pounds each, will blast off on a mission to study the sun's effects on Earth's magnetosphere. In addition, the ST5 trio will test several new technologies, including precision formation flying and micro propulsion systems nearly ten times more efficient than those currently available.

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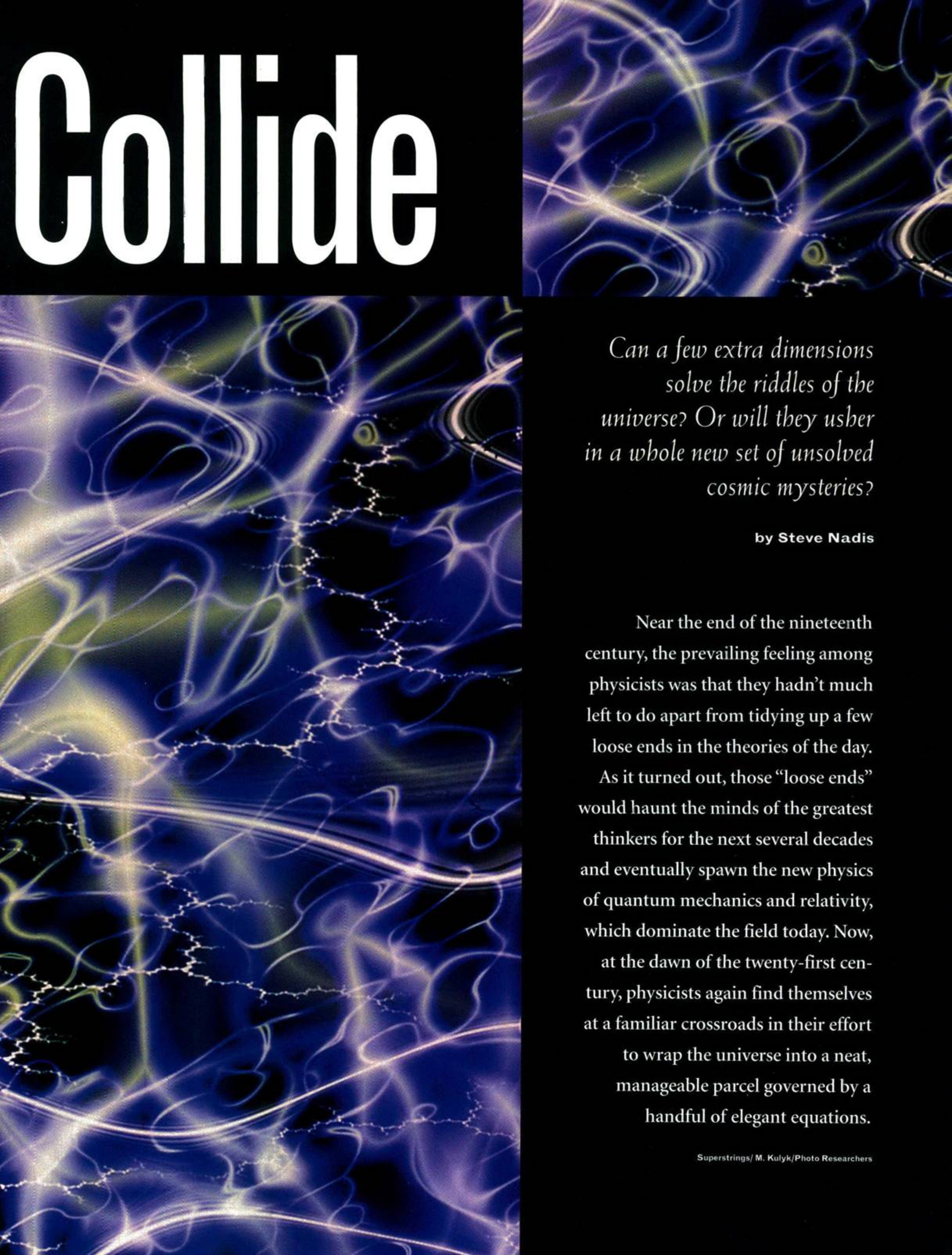
When Branes

Collide



Can a few extra dimensions solve the riddles of the universe? Or will they usher in a whole new set of unsolved cosmic mysteries?

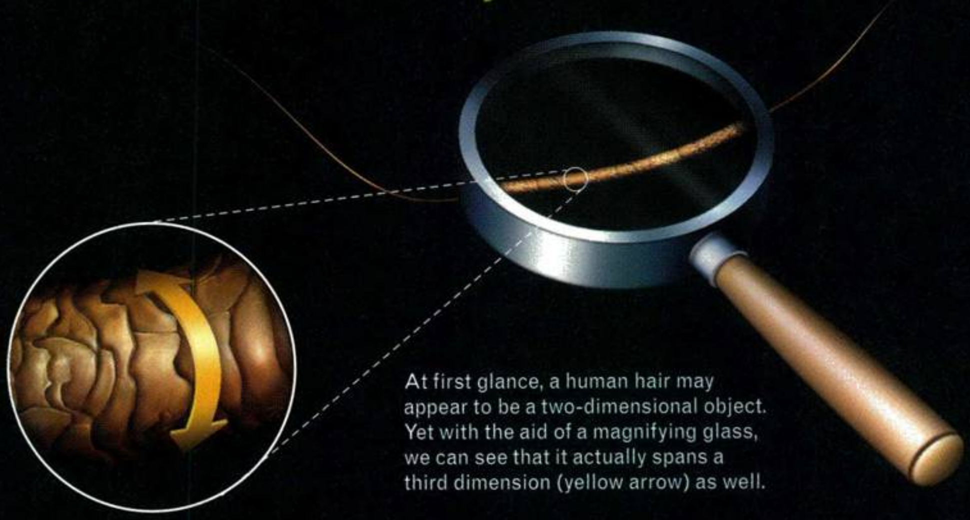
by Steve Nadis

Near the end of the nineteenth century, the prevailing feeling among physicists was that they hadn't much left to do apart from tidying up a few loose ends in the theories of the day. As it turned out, those "loose ends" would haunt the minds of the greatest thinkers for the next several decades and eventually spawn the new physics of quantum mechanics and relativity, which dominate the field today. Now, at the dawn of the twenty-first century, physicists again find themselves at a familiar crossroads in their effort to wrap the universe into a neat, manageable parcel governed by a handful of elegant equations.

Superstrings/ M. Kulyk/Photo Researchers

"The Big Bang theory has been incredibly successful, but it's really only a theory of what happened after the Big Bang."

Extra Dimensions: Where Are They?



At first glance, a human hair may appear to be a two-dimensional object. Yet with the aid of a magnifying glass, we can see that it actually spans a third dimension (yellow arrow) as well.

Though their influence may be huge, the truth is that many hidden dimensions may simply be too small for us to detect. And while the usual four dimensions of space-time may be infinite, this need not be so for any extra dimensions. In fact, extra dimensions may be wrapped up in spaces millions of times smaller that subatomic particles or perhaps as large as one millimeter. A human hair and a magnifying glass provide a good analogy (above).

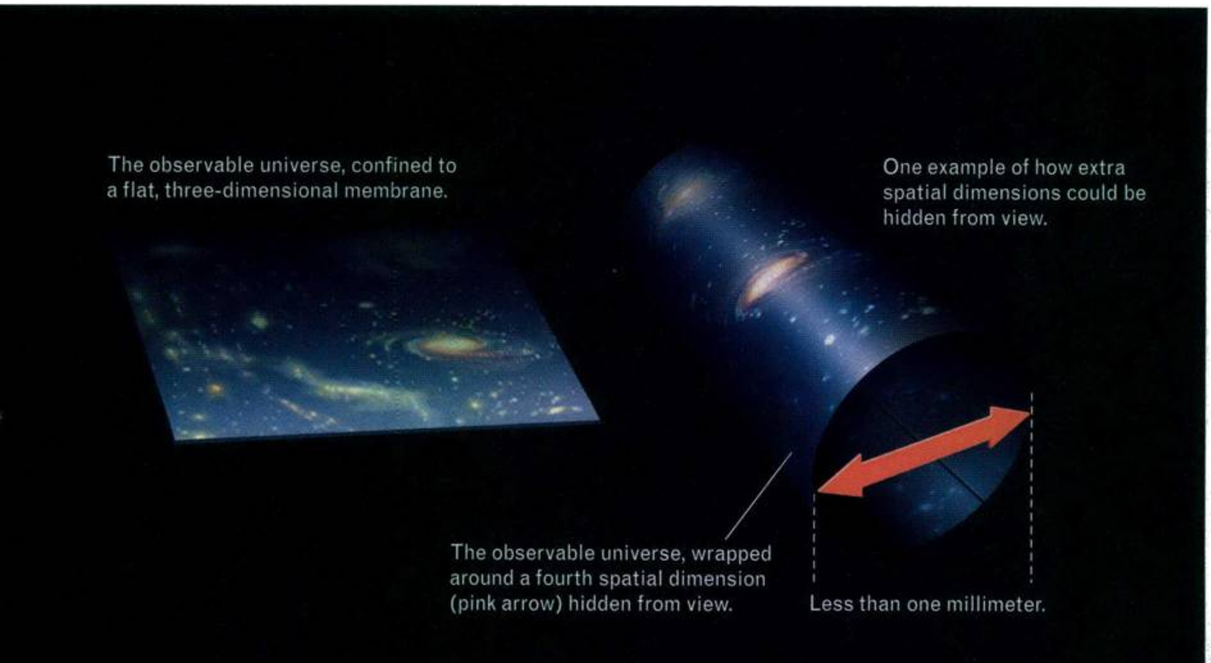
As it was nearly a century ago, fresh ideas are being born from this search for the final theory of everything. But this time, physicists are looking to higher dimensions for answers. And there are preliminary indications, at least on the theoretical front, that they may be on the right track after all.

In the realm of human experience, four dimensions (three spatial and one temporal) adequately describe reality. But what if there were, say, six more spatial dimensions hidden from our worldly view? If one of these extra dimensions was so large that it contained the entire visible universe while the other five were wrapped up so small that they couldn't be seen at all, would we ever be able to tell the difference? According to M-theory, the leading contender for the coveted title of Ultimate Theory, this just may be the case.

As it currently stands, M-theory is the latest, most fundamental version of superstring theory — a construct that holds that elementary particles (and, by extension, the entire universe) can be described by wave-like vibrations of fundamental entities called strings. As a matter of fact, M-theory unites five previously disparate versions of superstring theory into one coherent package. According to M-theorists, our universe lies on a three-dimensional membrane or "brane" that floats in a fifth dimension (with the fourth dimension being time). The theory also posits the existence of five higher spatial dimensions, which can generally be ignored, as they are wrapped up in tiny circles far smaller than the radius of a single proton (see "Extra Dimensions," above). As weird as these ideas may sound, several physicists have found recent success with applying M-theory to a host of cosmological questions.

University of Chicago cosmologist Michael Turner, for one, is intrigued by the prospect that the solutions to several cosmic conundrums may stem from the interactions of branes in higher dimensions. So far, conventional physics has been unable to tell us what the Big Bang really was, what caused it, or why the expansion of the universe is accelerating, Turner says. "The Big Bang theory has been incredibly successful, but it's really only a theory of what happened after the Big Bang." Moreover, the dark energy associated with cosmic acceleration, which is thought to comprise the bulk of energy in the universe, is equally mystifying. "Getting to the bottom of these mysteries with extra dimensions may sound like a stretch," he says. "But we need crazy ideas to get to the bottom of this."

A handful of scientists have already started putting M-theory to work on the most pressing of these problems. Princeton University physicist Paul Steinhardt — an early proponent of cosmic inflation, which purports that the universe suddenly underwent a smoothing period of rapid expansion, fractions of a second after the Big Bang — is now drawing on M-theory to offer an alternative to inflation. In addition, Steinhardt and his colleagues Justin Khoury of Princeton


The observable universe, confined to a flat, three-dimensional membrane.
One example of how extra spatial dimensions could be hidden from view.
The observable universe, wrapped around a fourth spatial dimension (pink arrow) hidden from view.
Less than one millimeter.

At present, no gravitational studies have probed distances smaller than 0.2 mm. If our observable universe were somehow wrapped around another large (millimeter-scale) spatial dimension, this could explain the more mysterious aspects of gravity such as dark matter and why gravity is so much weaker than other fundamental forces (see "Gravity on the Brane," page 39). Some physicists think we could detect extra dimensions by 2005.

All illustrations/ *Astronomy:* Elisabeth Rowan

University, Burt Ovrut of the University of Pennsylvania, and Neil Turok of Cambridge University have offered an explanation for what caused the Big Bang and what came before. According to their model — presented in March 2001 and dubbed the ekpyrotic scenario, after the Greek word "ekpyrosis" meaning conflagration — the Big Bang could have been the by-product of a fiery collision between two flat and parallel branes drifting through the fifth dimension (see "Megaverse Grand Slam," page 38).

In principle, there's no restriction against the universe emerging from such a megadimensional head-on collision. Sufficient energy and heat would be generated in such an event to fuel the observed expansion of the universe, without inflation. And the temperature and density fluctuations that astronomers see today could be attributed to quantum wrinkles on each of the branes, making some regions hotter than others.

In taking on a sacred cow like inflation, Steinhardt and company were bound to garner a strong reaction. The first came from Stanford University inflation theorist Andrei Linde. Along with his Stanford colleague and wife Renata Kallosh and Lev Kofman of the University of Toronto, Linde published an online critique a little more than a week after the first ekpyrotic paper was posted. (Visit www.astronomy.com to read Linde's critique.) Linde, among others, is skeptical of how the density fluctuations on either brane could survive the creation of a "singularity" — a point of infinite temperature and density where time stops and conventional physics breaks down — caused by the brane collision. "That would be like throwing a chair into a black hole, which would vaporize the particles of the chair, and saying it somehow preserves the shape of the chair," he says.

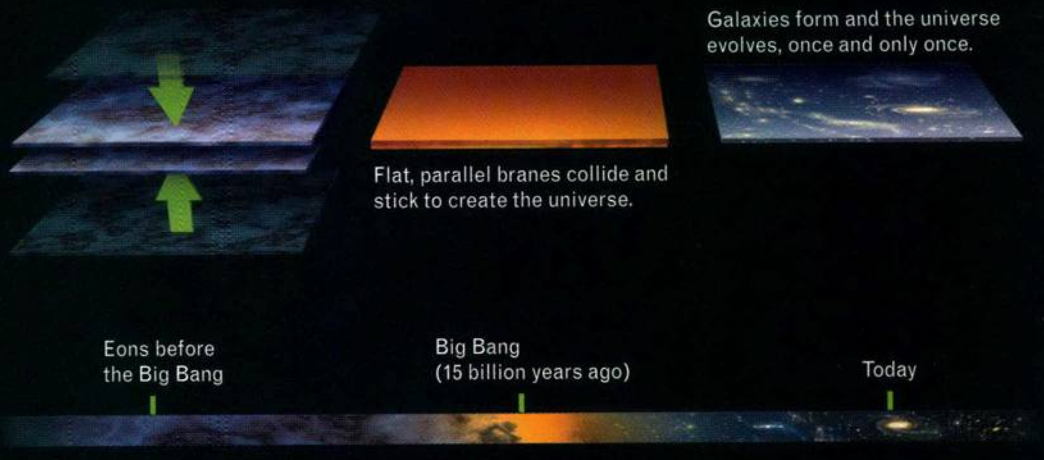
"What looks like a singularity in four dimensions may not be one in five dimensions," counters Steinhardt. "When the branes crunch together, the fifth dimension disappears temporarily, but the branes themselves don't disappear. So the density and temperature don't go to infinity, and time continues right through. Although general relativity goes berserk, string theory does not. And what once looked like a disaster in our model now seems manageable."

The ekpyrotic scenario has also come under attack because of its stringent set of initial conditions, requiring that the two branes be perfectly homogenous, flat, and parallel. "If you start with perfection, you might be able to explain what you see," Linde says. "But you still have to answer the question: Why must the universe start out perfect?"

Inflation rests on assumptions as well, Steinhardt says. "It works over a broader range of initial conditions, but not an infinite range." What he and his collaborators are proposing is conceptually and philosophically different, he adds. "We're saying there is this whole prehistory to the universe, an immense period of time before

Megaverse Grand Slam

The Big Crash: Ekpyrotic Model



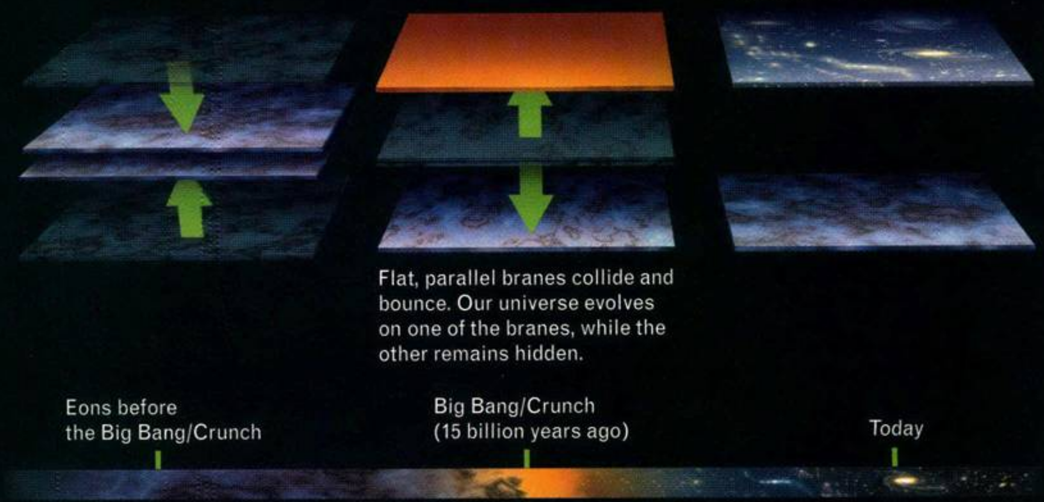
Galaxies form and the universe evolves, once and only once.

Flat, parallel branes collide and stick to create the universe.

Eons before the Big Bang
Big Bang (15 billion years ago)
Today

Bringing Back the Bounce: Cyclic Model

Due to the finite separation between them, the branes could collide over and over in cycle of creation and destruction.



Flat, parallel branes collide and bounce. Our universe evolves on one of the branes, while the other remains hidden.

Eons before the Big Bang/Crunch
Big Bang/Crunch (15 billion years ago)
Today

M-theory opens new avenues for probing the history of the universe by abandoning the notion that the Big Bang is the origin of space and time. Building on their ekpyrotic model (top), Paul Steinhardt and his colleagues recently developed a cyclic model of universal genesis (bottom). The cyclic model states that, rather than sticking after collision, parallel membranes (one with positive tension and the other with negative tension) immediately separate. Our universe evolves on one of the branes, undergoing cosmic acceleration for trillions of years. Eventually, the universe becomes smooth, empty, and flat, with a total energy near zero. Since the megadimensional gap is never closed, the process may repeat.

the Big Bang that is exponentially longer than the inferred age of our universe, during which these branes could flatten themselves into their most symmetric, lowest energy state." After the collision, there would also be more time for the branes to settle into equilibrium and reach a uniform temperature.

But before astronomers race off to replace inflation with colliding branes, MIT physicist and inflation originator Alan Guth has warned that the two scenarios need not be mutually exclusive. In fact, they may complement each other. "In the long run, I think it's inevitable that string theory and M-theory will need to incorporate inflation, since inflation seems to be an obvious solution to the problems it was designed to address — that is, why the universe is so uniform and flat," he says.

According to the original so-called "branefall" scenario conceived in 1998 by New York University physicist Gia Dvali and Cornell physicist Henry Tye, standard inflation could still occur during the slow-moving phase when two parallel branes slowly drift toward each other, because the attractive tug between branes — owing to gravity and other string forces — provides a source of potential energy that stays virtually constant, even with space expanding like mad. One virtue of the model is that it presents a geometrical picture of where the energy that sustains inflation comes from.

Yet Turner, for one, is still not completely convinced that floating branes can solve these outstanding cosmic puzzles. "It doesn't take a genius to say that all of the ideas out there today are wrong — or incomplete, at best. We're still at a very early stage of understanding the extra dimensions (assuming they exist) and their cosmological implications."

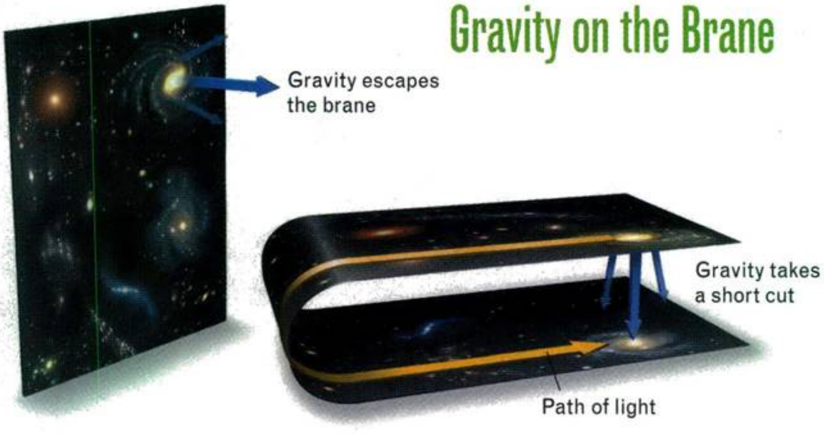
No one disputes the proposition that M-theory is a work in progress. And since it's being billed as a "theory of everything," it could take a long time to nail down the details. "Even though we don't know the full theory, there's still a lot we can do with confidence," says Tye. "In the same way, we know that Newton's laws are just part of the story, but we use them all the time. They work fine so long as you pick the right regime."

Columbia University's Brian Greene agrees that the new physics is still taking shape, but considers the interface between cosmology and string theory to be "the most fruitful place to be working today." Cosmology, he says, offers the best opportunities to test ideas from M-theory and string theory, because the energy produced in accelerator experiments is more than a quadrillion times too small. "We've been working on this theory for more than two decades with no new data."

By searching for specific features in the Cosmic Microwave Background, Greene and his colleagues hope to find "observable signatures that could tell us we're working with the right theory." "It would be nice to know I haven't devoted my career to something that is garbage — that we just might have a tool to apply to questions, such as the origin of the universe, that we couldn't get at before," says Greene.

"It doesn't take a genius to say that all of the ideas out there today are wrong — or incomplete, at best."

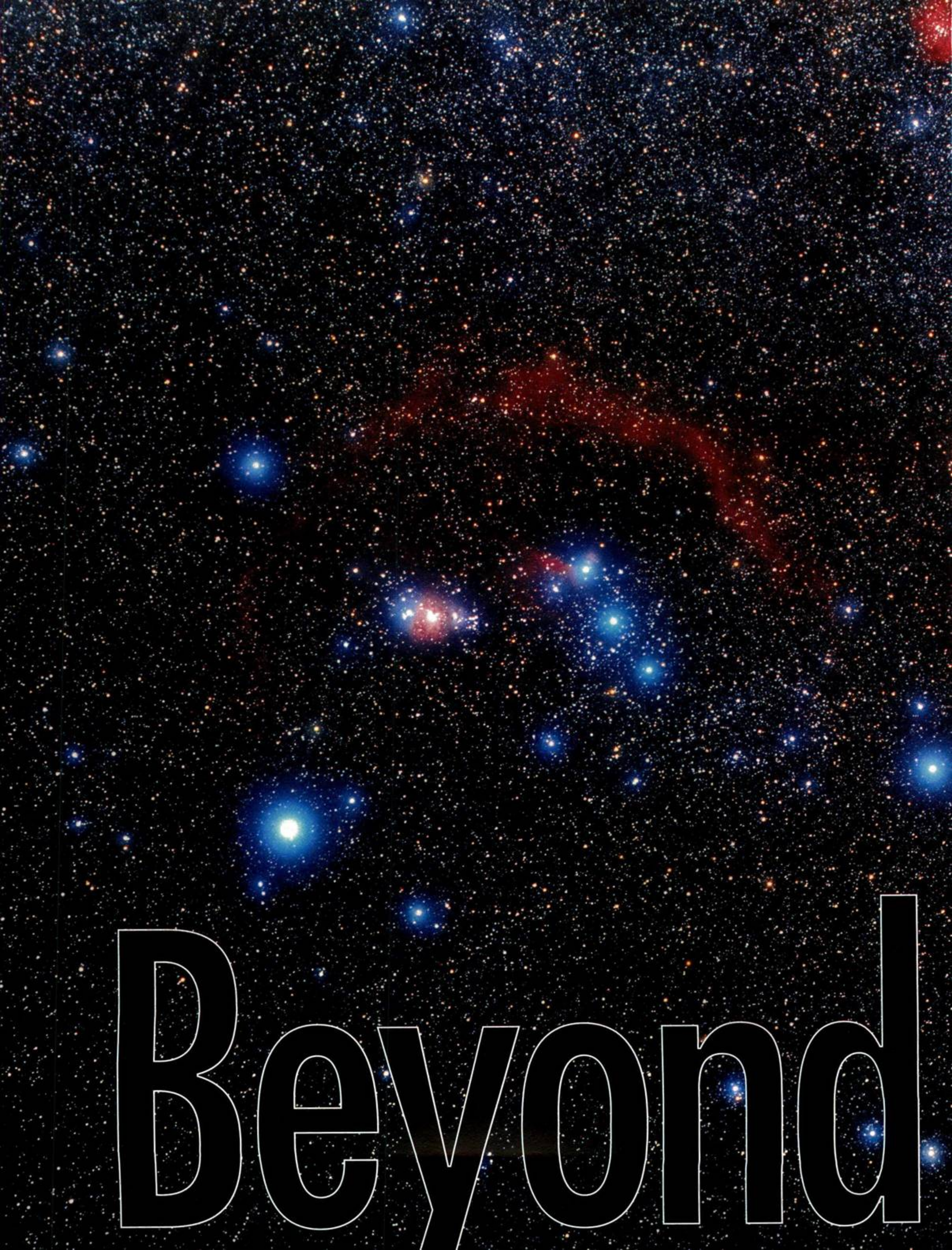
Gravity on the Brane



According to M-theory, the particles that comprise the universe, including photons, are confined to the brane they were created on. That is, except for gravitons (the yet-undiscovered carriers of gravitational force), which can drift into extra dimensions.

Therefore, with the ability to carry information to alternate dimensions, gravity may offer a unique window into megadimensional space where parallel universes roam.

"We're like ants stuck to a table, oblivious to higher dimensions we cannot experience," explains New York University physicist Gia Dvali. A nearby brane, of fold in the brane, concealed by extra dimensions, might provide the gravitational pull commonly attributed to dark matter, Dvali adds. And the current acceleration of the universe might be due to gravity leaking into extra dimensions over cosmological distances.



Beyond

the Pale

When it comes to color in the cosmos, you can't always believe what you see.

by Neil F. Comins

Glimpsing the many different hues found in the night sky has likely been part of the astronomical experience since the first time a keen-eyed stargazer began making systematic observations of the sky thousands of years ago. But next time you stare up at the brilliance of the heavens on a clear night, keep one note in mind — starlight is spun and tossed so much by intervening matter and our visual systems that you shouldn't always believe what you see.

A casual glance skyward reveals only two things about stars: They form patterns like Orion and the Big Dipper, and they differ in brightness. Most observers won't see star colors until actively studying these celestial wonders for some time. Indeed, most people perceive stars

A long-exposure image of the constellation Orion scintillates the visual sense with a medley of colors.

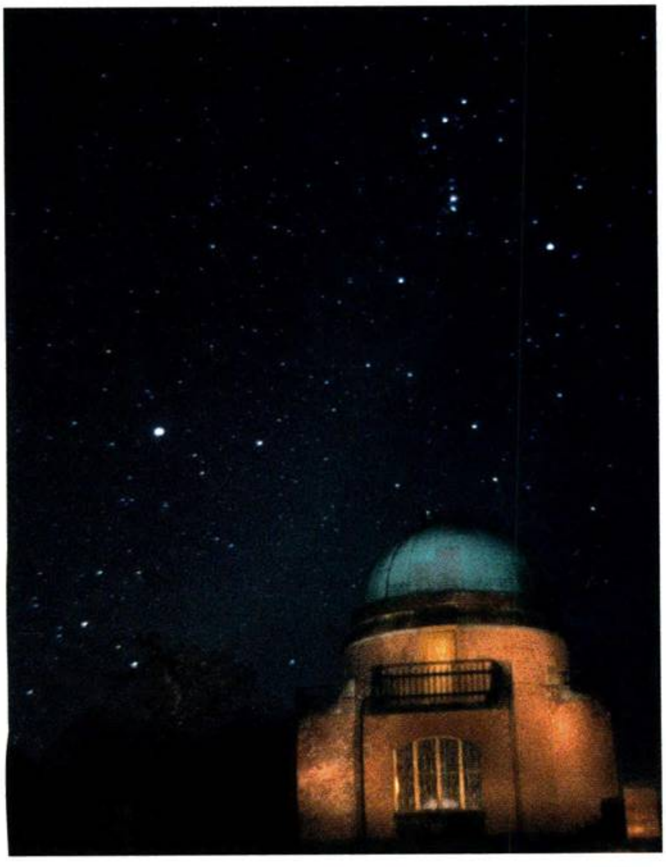
Bill and Sally Fletcher

as the same color — usually white. Nevertheless, many stars glow in distinct colors, best seen through binoculars or a telescope and when they float near other stars that then serve as contrast. Furthermore, apparent star colors change as stars twinkle (twinkling is caused by changes in the density of Earth's atmosphere.) For example, Betelgeuse, the bright ruddy star in Orion, changes color noticeably as it twinkles. Searching for colors can make observing the night sky much more interesting, and knowing in the back of your mind that the star colors we see provide unrealistic representations of the stars makes it all the more fascinating.

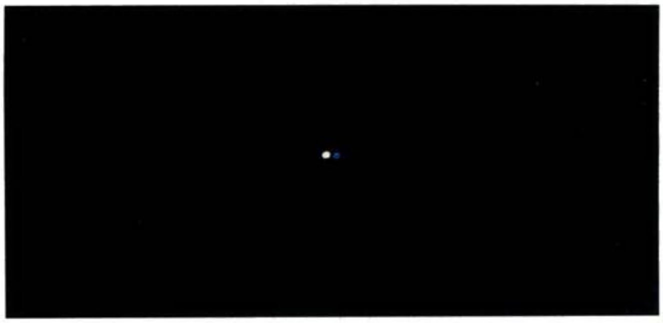
Stars commonly appear white for a number of reasons. First, by the time a star's light reaches us on Earth it shines down with fairly low intensity — so faint, in fact, that our color vision is unresponsive. The color-sensitive cells in our eyes, called cones, require a relatively bright light source for activation. Even the brightest of stars emit barely enough light to stimulate our cones. So we see most stars with our much more sensitive rod cells, which just so happen to be color-blind. We interpret light received by the rods as either "white" or various shades of gray.

Secondly, "white" is a nebulous concept at best; it appears differently under changing light levels and/or contrasting colors. To see this point just try to look at something you think is white, like a wall. Then take a piece of white paper, like the page of this magazine, and hold it up to your white object. Although we call them both "white," they are clearly not the same color. Likewise, it is hard to see hints of any color in even the brightest stars unless there is some contrast, such as other stars of different colors nearby.

Another issue is that star-color perception is influenced greatly by our expectations. We often don't see stars in color in part because we simply are not expecting to see them that way. We can aid our color receptors by knowing what to look for. People with normal color vision, once they know where to look, can begin picking out stars with many different colors.



This wide-angle photo of Orion reveals little of the blue, yellow and ruddy hues that light up deeper exposures of the constellation. The brightest stars in Orion reveal nice colors in a telescope's eyepiece; even the Orion Nebula appears a misty gray-green. Ales Kolar



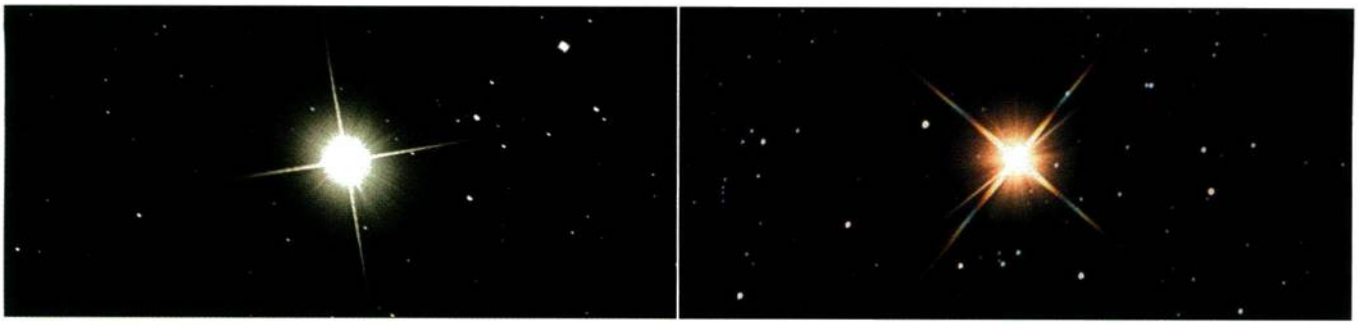
Double star Albireo: Contrast between the primary star and its deep-blue companion helps to show off the color of each. Ales Kolar

To understand more about observing star color, we need to review some essential properties of light. Visible light and all other types of electromagnetic radiation, namely radio waves, infrared, ultraviolet, x-rays, and gamma rays, can be thought of as particles called photons. But each photon also consists of a series of waves, all with the same wavelength. The wavelength of any photon is defined as the distance from the peak of one wave to the peak of the next. And, it is wavelength that determines in what color the mind will "see" the photon. Additionally, the shorter a photon's wavelength, the higher its frequency, and the more energy it packs. Radio waves, with the longest wavelengths, carry the least energy, while gamma rays are the most energetic.

Contrary to our impressions that each star is usually a single color, stars emit all visible colors. More curiously, even when viewed through a powerful telescope, a star's apparent color is often not the color it emits most robustly.

Consider the journey of light from its birthplace in a star's deep nuclear furnace to the eyes of an earthly beholder. All the photons emitted by the star were created in its central core where the tremendous pressure generated by the star's bulk provides enough energy for particles to fuse together. Such fusion transforms elements and produces a constant barrage of gamma-ray photons and neutrinos (neutrinos are included only for completeness; they have no bearing on our discussion of color perception).

Gamma rays — photons with extremely short wavelengths — are invisible, yet we still see stars shine. How? Some of these gamma rays get converted to visible light by the time they pierce the star's surface. As these highly energetic rays move from the stellar interior, they slam into numerous particles on the way. These particles respond by bounding away with some of the gamma ray's initial energy. So the photon leaves such an encounter with less energy — hence a longer wavelength — then before it struck the particle. The outward force of a star's escaping photons — known as radiative pressure — is also a part of what prevents stars from collapsing under their enormous masses.



Arcturus (left) appears more yellow than the much cooler Betelgeuse (right), which here appears orange-red. John Chumack

It takes about 170,000 years for the energy of a newly created gamma ray to finally reach a star's surface. As it loses energy on the way out, the photons that finally emerge have a wide variety of lower energies and longer wavelengths than their progenitor gamma rays. In fact, many photons leave their parent stars in the part of the electromagnetic spectrum that would appear to nearby observers as quite colorful.

In 1901, Max Planck showed that any naturally radiating objects, from stars to beauty queens, emit photons at all wavelengths. He determined that such objects each shine with characteristic peak intensity at one wavelength or another, a characteristic that is ultimately determined by the object's surface temperature.

Different stars have different surface temperatures and therefore different peak colors. The hotter an object, the shorter (we say "the bluer") the wavelength of its peak; the cooler the object, the longer (i.e., "the redder") its peak wavelength. Therefore, by determining the peak wavelength in the emitted color of a star, astronomers can use Planck's law to calculate its surface temperature — an essential measure in understanding the star's evolution.

For a concrete example, consider the star Arcturus in Boötes. It is easy to find; just follow the arc of the Big Dipper's handle to the first bright star ("Arc to Arcturus"). Arcturus, with a surface temperature of 8144° F (4780° K), has a distinctly yellowish hue both on film and to the trained eye when viewed high in the night sky. Betelguese, with a surface temperature of 5300°F (3200° K) appears to observers as a more orange-red star.

Let's follow the light from Arcturus's surface to our eyes. A few things come into play that will alter a star's apparent color as its light travels to us: interstellar gas clouds, Earth's atmosphere, and our visual systems.

As light travels through any gas, some of the photons at each wavelength (color) get scattered or redirected. The degree of scattering is dependent on the wavelength. Lord Rayleigh, the great British experimental physicist, first noticed this effect in 1871. Rayleigh soon determined that the shorter a photon's wavelength, the more it gets scattered

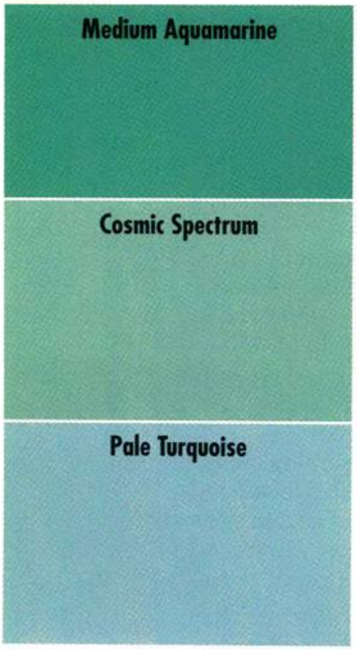
Cosmic Coloring

For a bit of fun, astronomers recently decided to mix starlight from hundreds of thousands of galaxies to approximate the "color" of the universe.

While researching star formation, Karl Glazebrook and Ivan Baldry of Johns Hopkins University added up the individual spectra of more than 200,000 galaxies observed by the 2dF Galaxy Redshift Survey. The product, which the pair calls the "cosmic spectrum," is the sum of the light from all those galaxies' stars.

The astronomers then used ophthalmological techniques to calculate how the human eye would perceive the combined light of all the 2dF galaxies. The result is a delicate green — just a few shades greener than the tone known as "pale turquoise."

"From one perspective, it's surprising that it turns out to be greenish, because there are no green stars," says Glazebrook. "But it's the large numbers of old red stars and young blue stars in the universe that gives us the green."



This might surprise anyone who has mixed red and yellow paints to get green or light designers who know that red and blue lights produce magenta. But according to Glazebrook and Baldry, "blue" stars are really blue-green and "red" stars are red-green. When light from blue and red stars are mixed, the result is white and a bit of blue-green.

In addition to producing the aesthetic result, the two astronomers believe their cosmic spectrum can help describe the history of star formation in the universe. Old and young stars show different spectral lines, and the intensity of these lines in the cosmic spectrum could reveal the relative numbers of young stars versus old stars. From this, the researchers will try to infer past rates of star formation.

The researchers believe that the overall color of the universe was bluer in the past, when hot, young stars dominated stellar populations. Currently in a green phase, the universe will eventually turn redder as stars age. — *Vanessa Thomas*

A sunset over Chicago, Illinois illustrates the beautiful and orderly effects of Rayleigh-scattering. David Rights

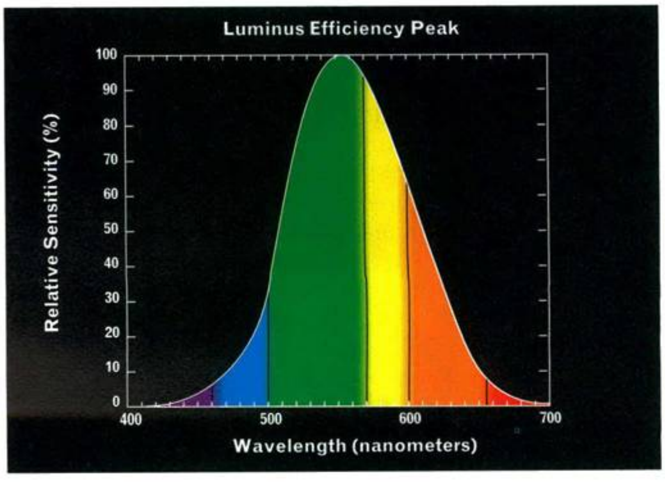
by intervening gas. In so-called Rayleigh scattering, violet light scatters most, followed by blue, green, yellow, orange, and red light. Therefore, stars appear more ruddy than they would without the influence of interstellar gas clouds or Earth's atmosphere. So Rayleigh-scattering in our planet's atmosphere washes out Arcturus's peak-intensity yellow light, and the star therefore appears a reddish-orange.

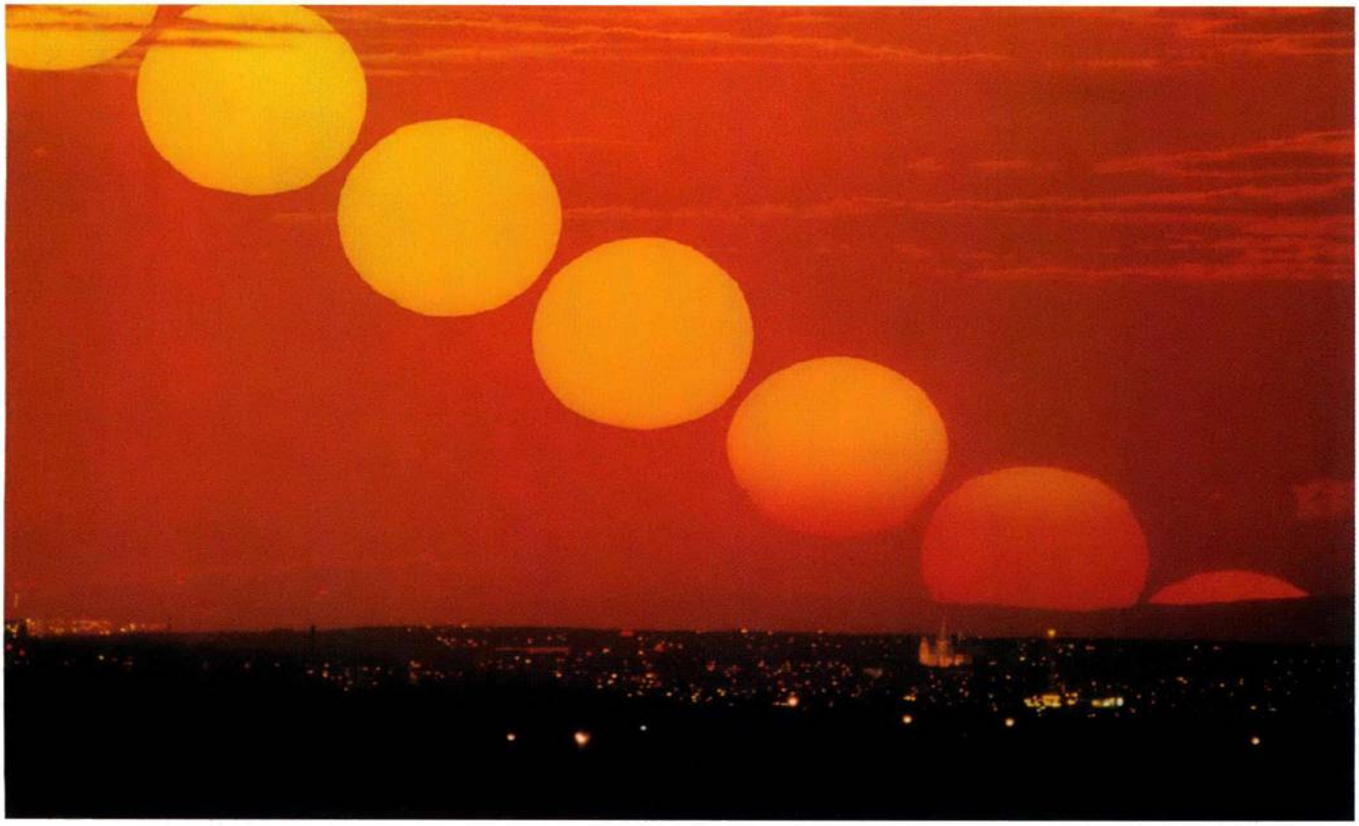
Another key factor in star-color perception is that our eyes do not respond to all colors equally. The human eye contains three types of color-sensitive cones, which, in turn, are each sensitive to different, overlapping ranges of colors. Although they are sometimes called "blue," "green," and "red" cones, they are actually most sensitive to violet, cyan (blue-green) and green, respectively. By combining the relative intensities of light absorbed by two or three types of cones, our brains generate our perception of color. For example, after our brains process the combined inputs from the "red" and "green" cones we perceive the colors orange and yellow. And the combined response of all three types of cones to different colors is called the eye's luminous efficiency. Our eyes have significantly different sensitivities to different colors. This can be represented by a curve with a single peak where our eyes perceive the most light of any color. That peak is in the yellow-green part of the spectrum. Indeed, our eyes respond most strongly to green and yellow, less to blue and orange, and least to violet and red.

The difference in our visual sensitivity to varying colors greatly influences our perception of star colors. From looking at the luminous efficiency peak, you can see that light from stars with peak intensities at short-wavelengths, or violet, will appear to us as more green or yellow than violet or blue, which would not be the case if our eyes were equally sensitive to all colors. Conversely, light from stars with peak intensities at long-wavelengths will appear less red and more orange or yellow.

Complicating our perception of star colors is that white, as you probably know, is not a color of the rainbow. When using our eyes' cones, we perceive some objects as white because of how our brains interpret the different intensities of the colors we see. It's a perception effect. Objects appear to have a specific color when they emit or scatter a limited range of colors or when the intensity of one color is much greater than the intensities of other colors. On the other hand, when light from an object has equal light intensities for the three types of cones in our eyes, we see white. Because of the intensities of the colors we receive from them, Procyon in Canis Minor and Polaris, the North Pole star, appear white even under magnification.

Another way objects appear white is if they overload our cones with too much energy. I once asked former astronaut





Pinky Nelson what the sun looked like from space — and therefore without the dampening effect of Earth's thick atmosphere. His reply was, "blindingly white." But the sun holds even more surprises.

If you ask most people (on Earth, of course) what color the sun is, they will say yellow or orange. But the peak of the sun's radiation is actually in the blue-green part of the spectrum. The harmless, fleeting glimpses of the sun we each get on sunny days lead to different perceptions of its "color." These depend on where we see it. For example, seeing the sun high in the sky gives the impression it is white or yellow. Seeing it low in the sky, we perceive the sun as orange or red. It never appears turquoise because so many of its shorter-wavelength violet and blue photons are scattered away in the atmosphere before its radiance reaches our eyes. But, curiously, these scattered photons do make the air glow, which creates the blue sky. (There are a few other reasons why the sky looks blue — for example, our eyes are more sensitive to blue light than to violet light, and the sun emits many more blue photons than violet ones.)

At Earth's surface the color peak of the sun's intensity is different from what it is in space. Nevertheless, down here its peak is still far into the green part of the spectrum. To understand why the sun appears yellow, we consider the effects of its light on the three types of cones. There is much less direct blue sunlight than either green or red sunlight at Earth's surface. This makes sense, of course, because the blue and violet photons are strongly Rayleigh-scattered. The violet-sensitive "blue" cones see very few photons compared to either of the other two types of cones. However, there is little difference in the number of photons detected by the "green" and "red" cones. The "red" and "green" cones send green and red signals to our brain, which then combines them to create the perception of yellow.

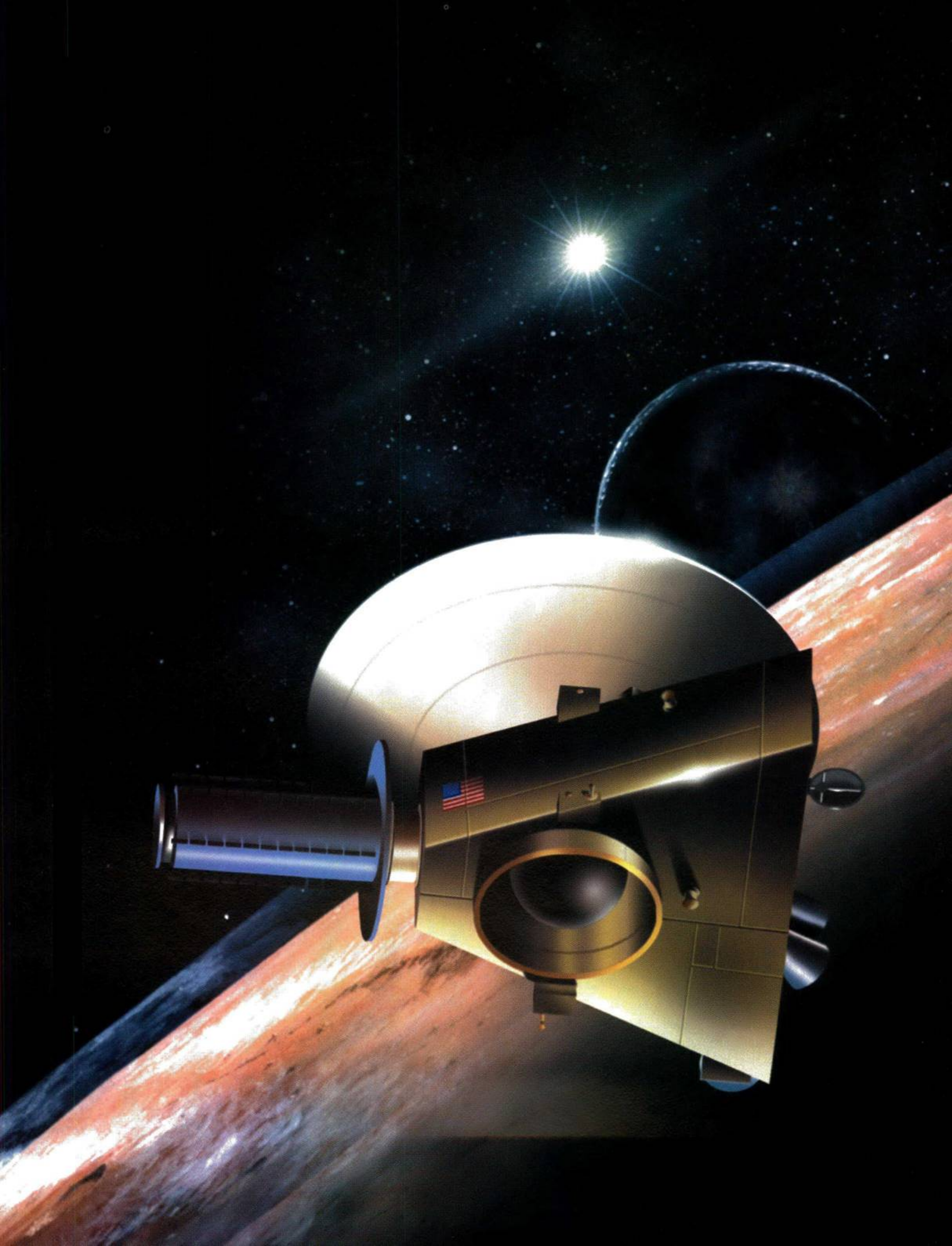
The setting sun descends and slowly changes color from yellow, to yellow-orange, then red as it sinks into Earth's atmosphere. Ales Kolar

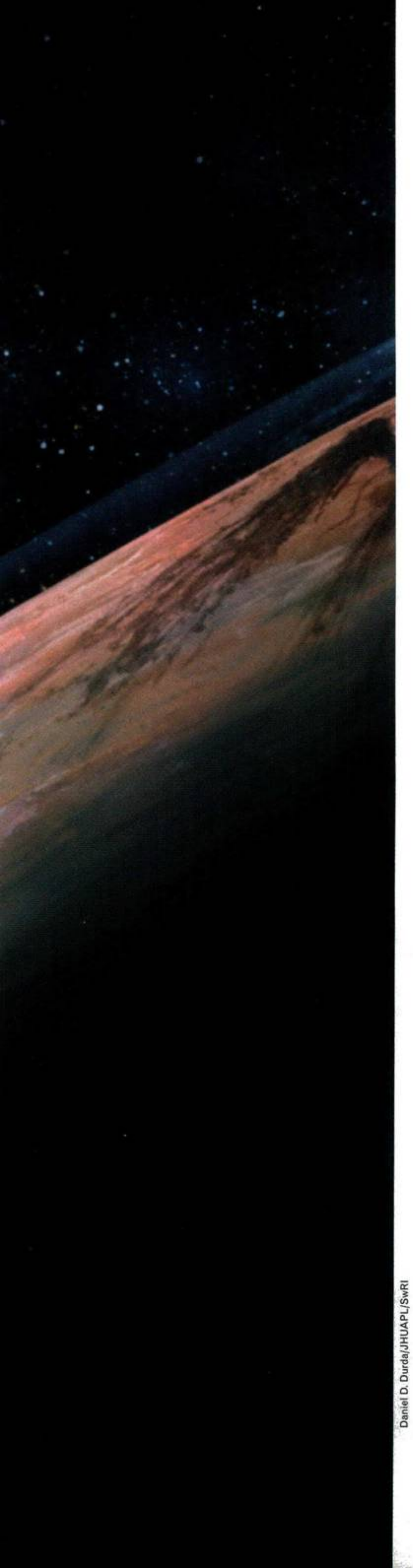
The sun looks orange or red when viewed close to the horizon because at these locations its light passes through more air than when seen overhead. With the sun low in the sky, the air Rayleigh-scatters more of all photons before the light reaches our eyes. The farther down the sun goes, the more the green, yellow, and even orange wavelengths are scattered, making it appear redder (recall that red light is scattered least).

The sun also appears dimmer as it sinks in the sky compared to when we see it through the thinner layer of the atmosphere high up. Can you guess what color Arcturus has when seen low in the night skies?

Therefore, our color perception of starlight is affected by several phenomena between the time the light is emitted and the time we interpret it. Understanding these effects, astronomers make corrections so they can accurately determine stellar surface temperatures. Our perception of the light from space is strongly biased by our eyes and brains. From all this we see that not all that we perceive is real, and not all that is real can be perceived. ■

Neil F. Comins is professor of astronomy and physics at the University of Maine. He is author of What If the Moon Didn't Exist? *and coauthor of* Discovering the Universe, *4th edition, with William J. Kaufmann* III. *Professor Comins collects misconceptions about astronomy. You can share misconceptions that you have encountered with him at galaxy@maine.maine.edu. Go to www.astronomy.com to view a photo gallery of colorful sky images, which features a broad selection of the sky's most unusual and richly-hued subjects.*

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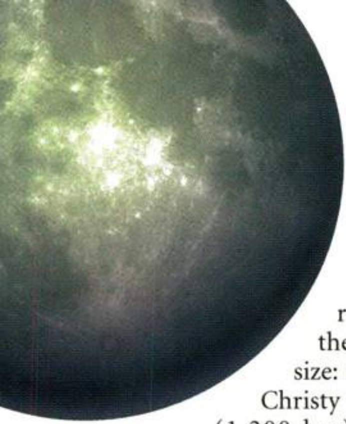
Pluto or Bust

NASA has finally given a tentative go-ahead for a mission to the last unexplored planet.

by Andrew Cheng

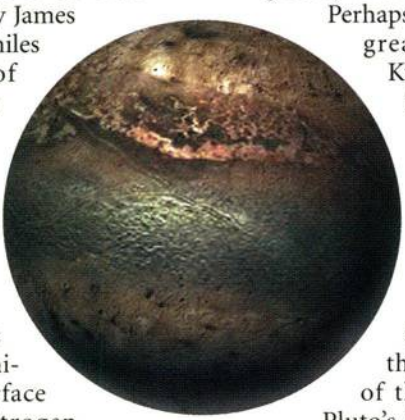
In the last quarter of the 20th century, great voyages of discovery revealed an impressive array of worlds in the outer solar system. From the violent volcanoes erupting on Io to the intricate rings encircling Saturn, the wonders unveiled by this flotilla of robotic explorers amazed even the scientists involved.

But the initial reconnaissance of the solar system remains incomplete — no spacecraft has reached Pluto, the ninth planet. That may soon change. In November 2001, following an open competition among planetary scientists, NASA selected a mission concept called New Horizons designed to make the first exploration of Pluto and the equally intriguing Kuiper Belt. NASA has provided $30 million for a detailed study of the project during the current fiscal year. If Congress continues funding in 2003 — currently a big if — the mission should lay bare the last unexplored corner of the solar system.



When Clyde Tombaugh of the Lowell Observatory discovered Pluto in 1930, scientists and the public immediately accepted it as the ninth planet. Yet Pluto resembles no other planet. With a diameter of nearly 1,500 miles (2,400 km), Pluto easily ranks as the smallest planet. Yet it has the largest moon relative to its own size: Charon, discovered by James Christy in 1978, spans 740 miles (1,200 km), about half that of Pluto. Charon's so big in comparison to Pluto that the system's center of mass actually falls between the two bodies, making Pluto-Charon the only binary planet in the solar system.

The discovery of Charon helped planetary scientists pin down some of the properties of these enigmatic worlds. Both have densities of about 2 grams per cubic centimeter, indicating a composition dominated by rock and water ice. Pluto's surface appears covered with bright ices of nitrogen, ammonia, carbon monoxide, and water. And Pluto possesses a thin atmosphere, at least when it travels on the inner part of its orbit and the sun evaporates some of those ices.



A Planet Unlike Any Other

Pluto certainly occupies a unique niche in the solar system. The inner solar system contains the four rocky, terrestrial planets — Mercury, Venus, Earth, and Mars — which reach from 0.4 to 1.5 astronomical units from the sun (one astronomical unit, or AU, equals the average Earth-sun distance, about 93 million miles). Just outside the orbit of Mars lies the main belt of asteroids. Farther out, the four gas giant planets (Jupiter, Saturn, Uranus, and Neptune) form a second major zone that extends between 5 and 30 AU.

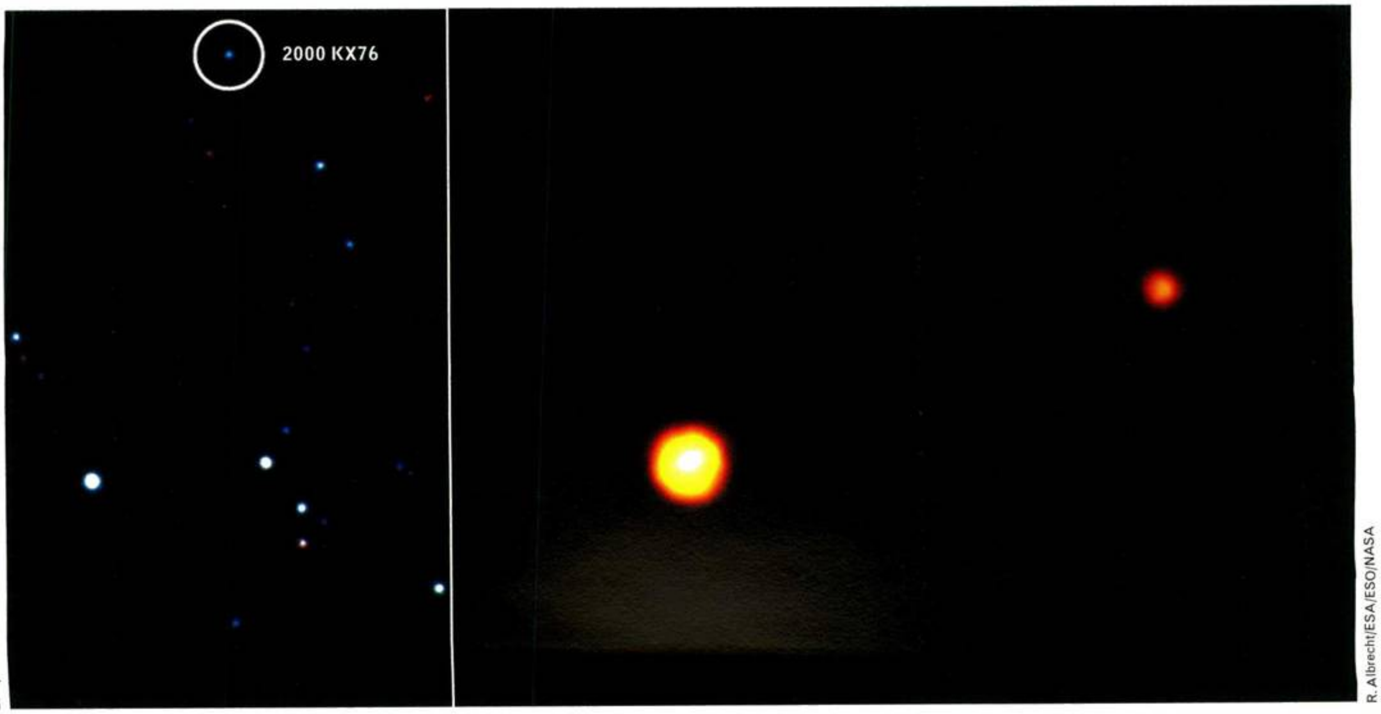
The highly eccentric orbit of Pluto takes it from just inside 30 AU — closer to the sun than Neptune — to almost 50 AU. Planetary scientists call the vast realm occupied by Pluto's orbit the trans-Neptunian region. An enormous number of icy bodies populates this region, forming what's called the Kuiper Belt. More than 500 Kuiper Belt Objects have been discovered since 1992, when David Jewitt and Jane Luu found the first (named 1992 QB_1). Kuiper Belt Objects greatly outnumber the asteroids of the main belt: Perhaps as many as 100,000 objects with diameters greater than 30 miles (50 km) exist in the Kuiper Belt compared with about 1,000 in the main asteroid belt.

Planetary scientists think that the icy worlds of the Kuiper Belt are remnants from the formation of the solar system. Many also suspect that Pluto and Charon are genetically related to the Kuiper Belt Objects — that Pluto originally condensed in the trans-Neptunian region and should be considered the largest member of the Kuiper Belt.

Pluto's importance to science derives both from its uniqueness as a planet and from its likely relationship to the Kuiper Belt, whose role in the origin of the solar system remains at best dimly grasped.

The Pluto-Charon system together with the Kuiper Belt

Small and distant, it's no wonder we know so little about Pluto, Charon, and the Kuiper Belt. The best images taken from Earth of Pluto and Charon (below) and a Kuiper Belt Object (2000 KX_{76}; below left) show how little we can learn about them without sending a robotic explorer.



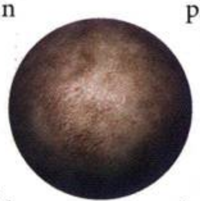
European Southern Observatory

R. Albrecht/ESA/ESO/NASA

make up the third major zone of the solar system — a zone now ripe for exploration. The New Horizons mission was designed for just this purpose. Led by Principal Investigator Alan Stern of the Southwest Research Institute, the New Horizons team includes scientists from the Johns Hopkins Applied Physics Laboratory, Ball Aerospace, NASA's Goddard Space Flight Center, Stanford University, and more than a dozen other institutions.

Off to Pluto

The New Horizons mission will be launched in January 2006 onto a trajectory that swings by Jupiter in March 2007. A gravity assist from the giant planet will send the spacecraft on to Pluto, where it will arrive in either 2015 or 2016. In the five years following the Pluto-Charon encounter, mission planners will target up to three Kuiper Belt Objects that lie along possible flight paths.



The New Horizons spacecraft will carry a powerful complement of science instruments. The PERSI remote sensing package will provide imaging and spectroscopy at visible, infrared, and ultraviolet wavelengths. The REX radio/radiometry experiment will communicate with Earth as well as measure the atmosphere and surface temperature. The PAM suite will analyze plasmas and high-energy particles in the planet's environment. Finally, the LORRI long-focal-length imager will take very high-resolution images — at closest approach, it will achieve a resolution several times better than the best Voyager images of Neptune's moon Triton.

The Pluto-Charon encounter will begin six months before New Horizons reaches its target. For a period of 75 days on either side of closest approach, images will surpass the best Hubble Space Telescope images now available. New Horizons will map the global geology of Pluto and Charon at a resolution of better than a mile (1 km) and will distinguish features as small as a football field (100 meters) in its highest resolution images. The spacecraft will also map the composition, distribution, and temperature of the surface ices as well as measure the composition, structure, and temperature of the planet's rarefied atmosphere. New Horizons will then make similar observations at up to three Kuiper Belt Objects.

The biggest question facing the mission is whether it will ever get off the ground. The $30 million appropriated this fiscal year gets the project going, but the Bush Administration has not requested any additional funding for next year — despite increasing the overall budget for planetary science. (For updates on the budget's progress, check out astronomy.com.) Although the fate of the New Horizons mission is unclear, those of us who have advocated a Pluto mission for more than a decade remain hopeful.

Historians of future centuries may well view our robotic exploration of the solar system as signal accomplishments of our age. Our sphere of knowledge has grown to include dozens of worlds previously seen as little more than blurry points of light in a telescope. With New Horizons providing the first up-close look at Pluto, Charon, and the Kuiper Belt, we have the opportunity to add several new worlds to this expanded sphere. ■

Compare the sizes of these small solar system objects (above, from left): the moon, Triton, Pluto, Charon, and the Kuiper Belt Objects 2000 KX_{76}, Varuna, and 1996 TO_{66}. Many scientists think that Pluto may prove similar to Neptune's odd and varied moon Triton (below).

Andrew Cheng of the Johns Hopkins Applied Physics Laboratory is the Project Scientist for New Horizons. Additional information on the New Horizons project can be found at http://pluto.jhuapl.edu and www.boulder.swri.edu/pkb.

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sky Show

may

Don't miss the planetary grouping of the decade.

by Martin Ratcliffe and Alister Ling

▶ Get a good look at this May's sky — *you won't see* anything like it for years to come. The bright planets are gathering for a brilliant show in the evening sky. April's lineup was impressive, but this month you can capture several planets in the same binocular field. The next series of multiple-planet groupings won't take place until 2020, when Jupiter and Saturn will share a small patch of sky once again. However, even that conjunction will be less spectacular because Mars and Mercury will not be in the area.

The bright planetary beacons Venus, Saturn, and Jupiter are guaranteed attention-grabbers this month. As luck would have it, Mercury simultaneously puts on its best evening show of the year — a performance wherein it's even brighter than orangy Mars.

Saturn, Venus, and Mars form a tight triangle in binocular-view from May 4 to 7. Watch how Saturn slumps below the climbing pair of Venus and Mars over the next week. Then, the crescent moon adds to an already dazzling visual feast from May 13 to 16.

This extraordinary planetary conjunction is easy to capture on camera. For film users, try slower speeds, such as ISO 100, so that you can make nice enlargements. Use a tripod to ensure a steady shot, and take a few exposures, ranging from 8 seconds to 1/15-second at f/4 to get one that's just right. Don't forget to zoom in for some close-ups. Remember that film is cheap and you won't have another chance at a spectacle like this for decades.

Capping off this planetary parade is Saturn's captivating occultation by the moon, which will occur on the morning of May 14.

While next month's solar eclipse is waiting in the wings, a warm-up event occurs on the morning of May 26 — a penumbral eclipse of the moon. Catch an unusually yellow moon setting just a few minutes after sunrise.

Watch the celestial hunting dogs Canes Venatici chase the Great Bear high overhead. Its rich galaxy fields are inviting when mild weather encourages pulling all-night observing sessions. In the dogs you can dig past Messier objects into the unusual shapes of Halton Arp's peculiar galaxies.

Pluto fans can stay up late and spy the frozen orb floating in the star fields of southern Ophiuchus. Beginners need an 8-inch scope and a lot of patience to spot this remote planet, while experts may relish the challenge of glimpsing Pluto in a 4-incher.

Swift shooting stars are the telltale signs of the annual Eta Aquarid meteor shower, the progeny of Halley's comet. Halley itself is invisible right now, but two other comets — LINEAR WM1 and Pons-Winnecke — are waiting to be captured from dark country skies.

Venus, Jupiter, Mars and the moon in conjunction in 1991. James R. Foster and Michael Stecker

May 2002

3 The moon passes 4° south of Neptune, 8 P.M. EDT
Mercury is at greatest eastern elongation (21°), midnight EDT

4 Last quarter moon is at 3:16 A.M. EDT
Venus passes 6° north of Aldebaran, 10 A.M. EDT
Mars passes 2° north of Saturn, 1 P.M. EDT

5 Eta Aquarid meteor shower peaks (page 60)
The moon passes 4° south of Uranus, 6 A.M. EDT

7 Venus passes 2° north of Saturn, 2 P.M. EDT
The moon is at apogee (251,955 miles from Earth), 3:14 P.M. EDT

10 Venus passes 0.3° north of Mars, 5 P.M. EDT

12 New moon is at 6:45 A.M. EDT

13 The moon passes 3° south of Mercury, 5 P.M. EDT (page 58)

14 The moon passes 1.1° north of Saturn, 4 A.M. EDT
The moon passes 0.6° south of Mars, 3 P.M. EDT
The moon passes 0.8° south of Venus, 7 P.M. EDT

15 The moon passes 1.1° north of Vesta, 8 A.M. EDT

16 The moon passes 2° north of Jupiter, 8 A.M. EDT

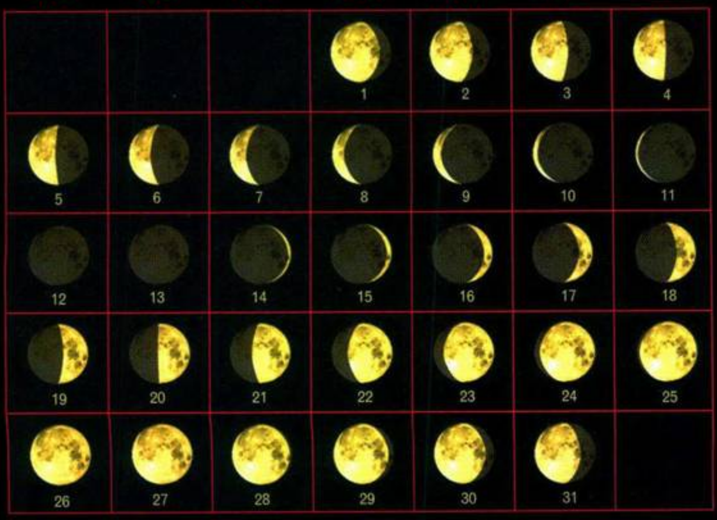
19 First quarter moon is at 3:42 P.M. EDT

23 The moon is at perigee (226,790 miles from Earth), 11:32 A.M. EDT

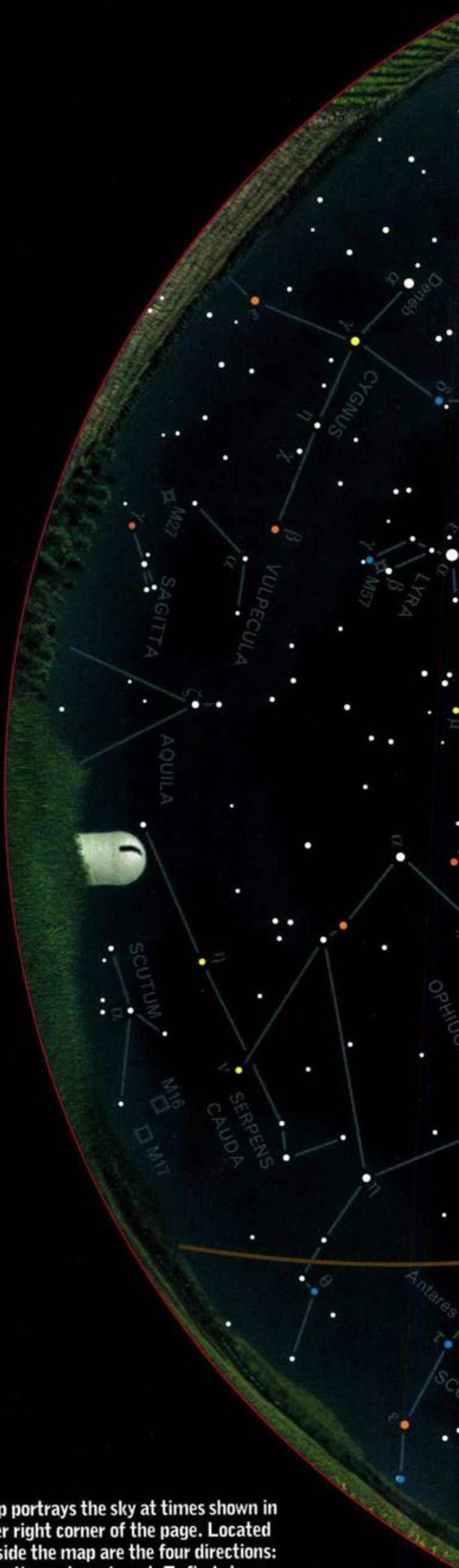
26 Full moon is at 7:51 A.M. EDT; penumbral lunar eclipse (page 60)

27 Mercury is in inferior conjunction, 3 A.M. EDT

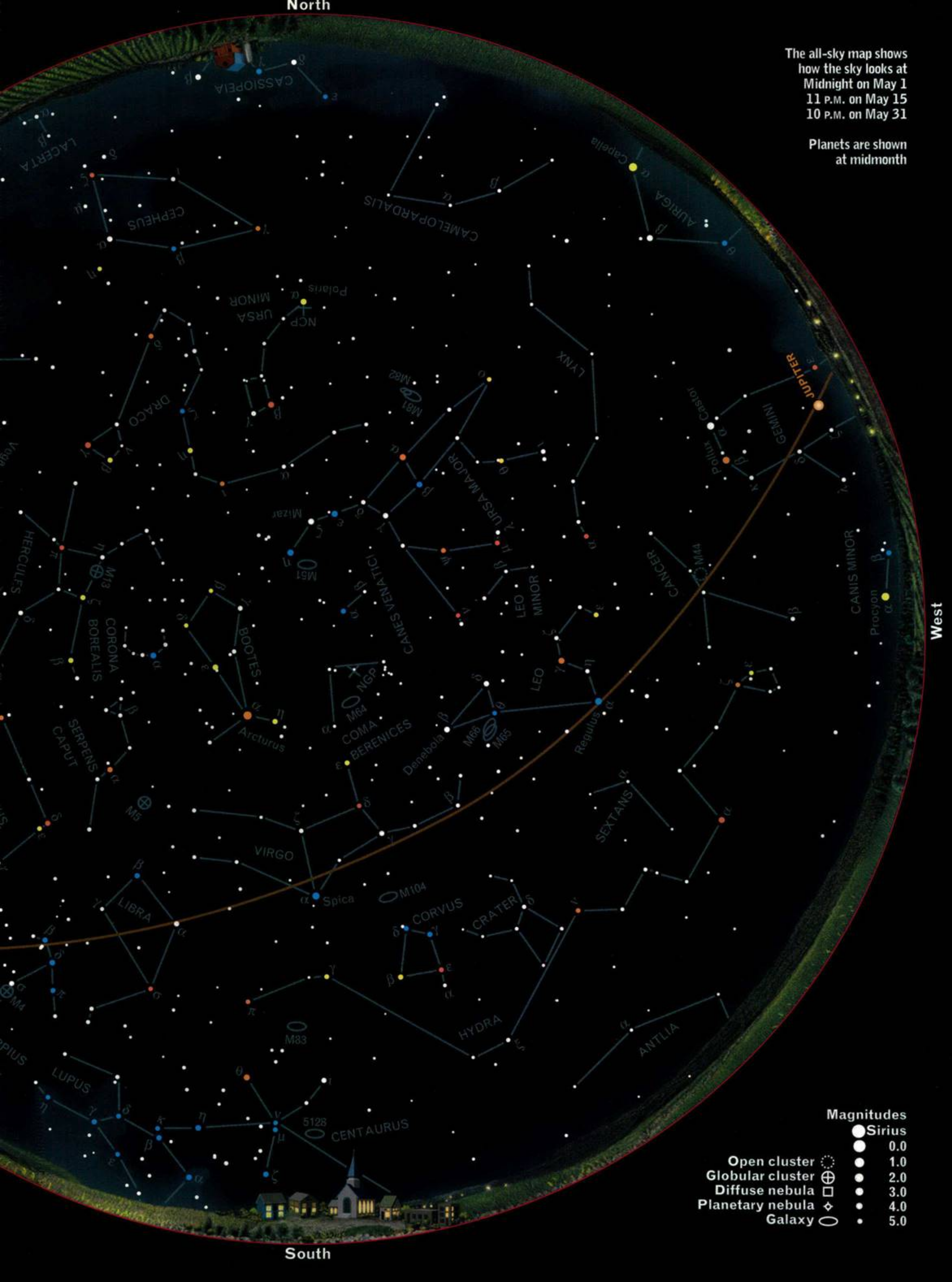
31 The moon passes 4° south of Neptune, 4 A.M. EDT



SUN.	MON.	TUE.	WED.	THUR.	FRI.	SAT.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

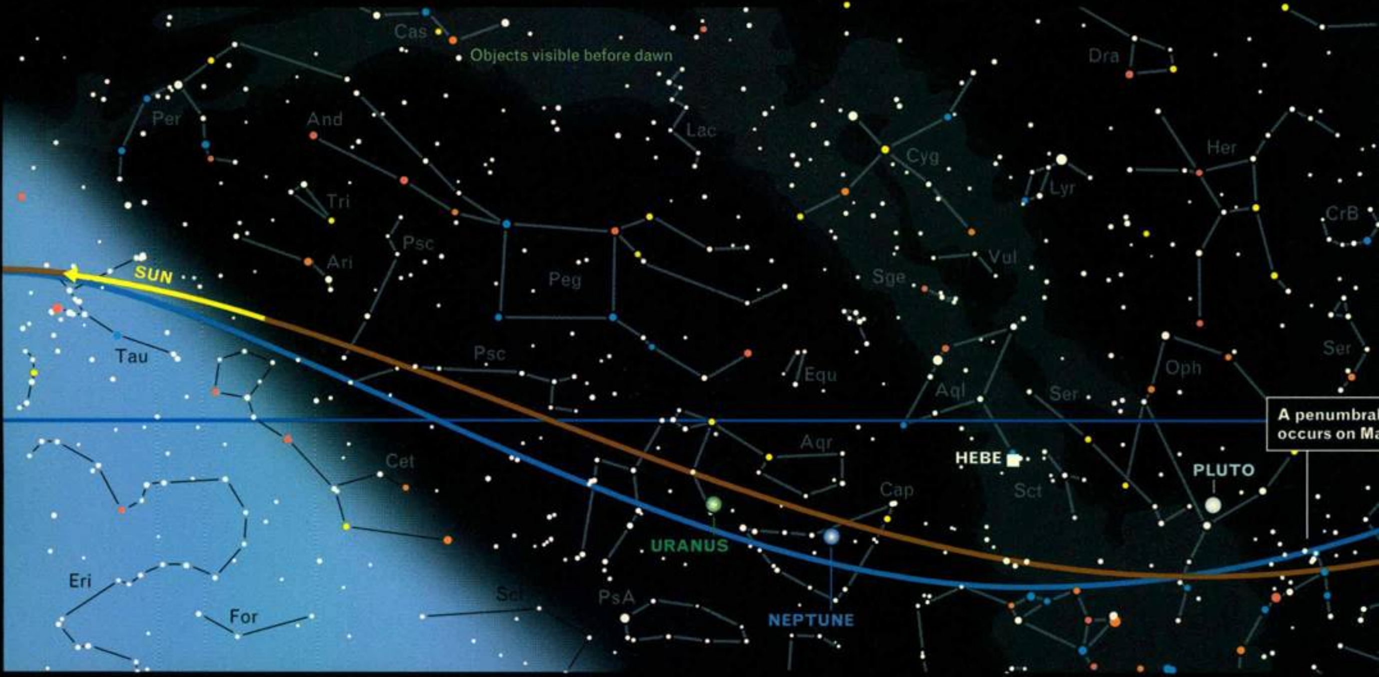

North
CASSIOPEIA
LACERTA
CEPHEUS
CAMELOPARDALIS
Capella
AURIGA
URSA MINOR
Polaris
NCP
DRACO
Vega
LYNX
M82
M81
JUPITER
Castor
Pollux
GEMINI
URSA MAJOR
Mizar
HERCULES
M13
M51
CANES VENATICI
LEO MINOR
CANCER
M44
CANIS MINOR
Procyon
West
CORONA BOREALIS
BOOTES
NGP
M64
COMA BERENICES
LEO
Arcturus
SERPENS CAPUT
Denebola
M66
M65
Regulus
M5
SEXTANS
VIRGO
Spica
M104
LIBRA
CORVUS
CRATER
M4
HYDRA
M83
ANTLIA
SCORPIUS
LUPUS
5128
CENTAURUS
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
Midnight on May 1
11 P.M. on May 15
10 P.M. on May 31

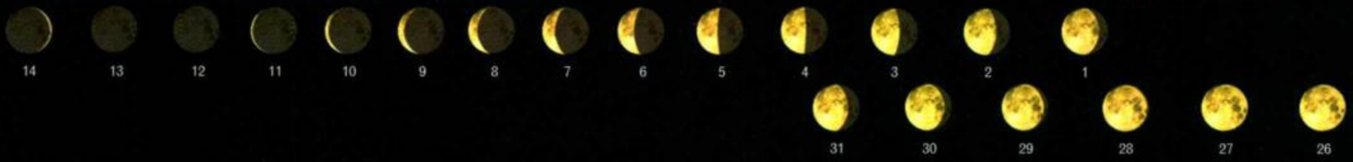
Planets are shown
at midmonth

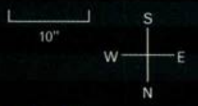
Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects

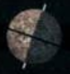

Cas
Objects visible before dawn
Per
And
Lac
Dra
Cyg
Her
Tri
Lyr
CrB
Ari
Psc
Vul
SUN
Peg
Sge
Ser
Tau
Psc
Equ
Oph
Aql
Ser
Cet
Aqr
HEBE
PLUTO
Sct
Cap
URANUS
Eri
Scl
PsA
For
NEPTUNE

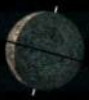
A penumbral
occurs on Ma

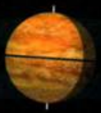

14
13
12
11
10
9
8
7
6
5
4
3
2
1
31
30
29
28
27
26

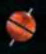


PLANETS	MERCURY	MERCURY	VENUS	MARS
Date	May 1	May 15	May 15	May 15
Magnitude	0.0	2.2	−3.9	1.7
Angular Size	7.3''	10.4''	11.9''	3.9''
Illumination	47%	12%	86%	98%
Distance (AU) from Earth	0.920	0.644	1.401	2.421
Distance (AU) from Sun	0.355	0.430	0.718	1.589
Right Ascension (2000.0)	3h52.5m	4h32.2m	5h30.5m	5h20.8m
Declination (2000.0)	22°51'	23°26'	24°36'	24°02'



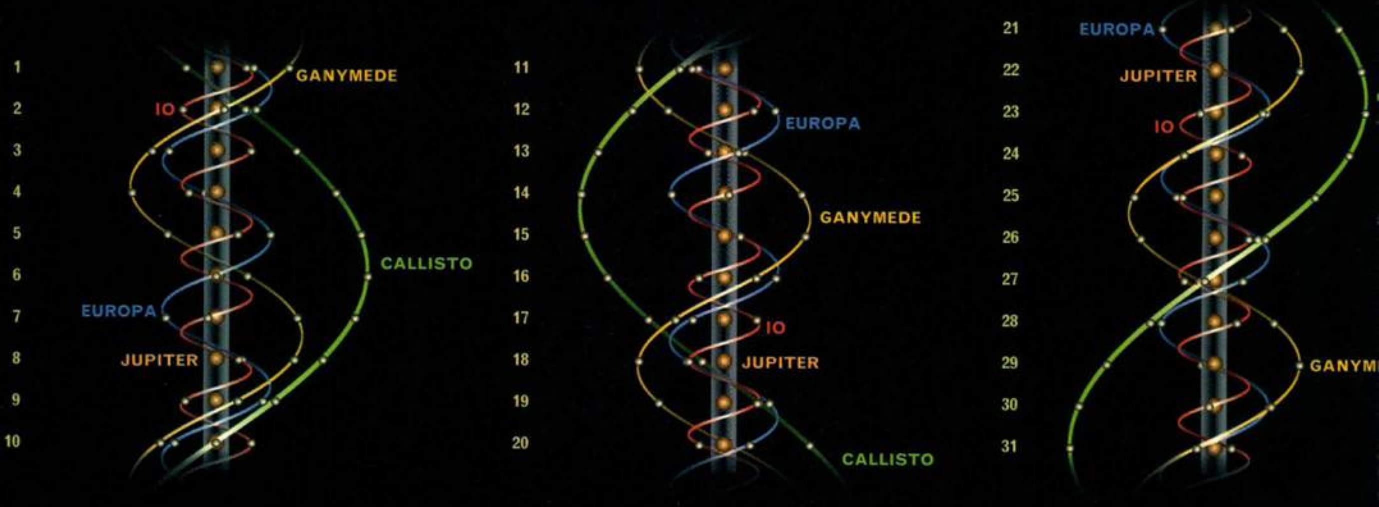




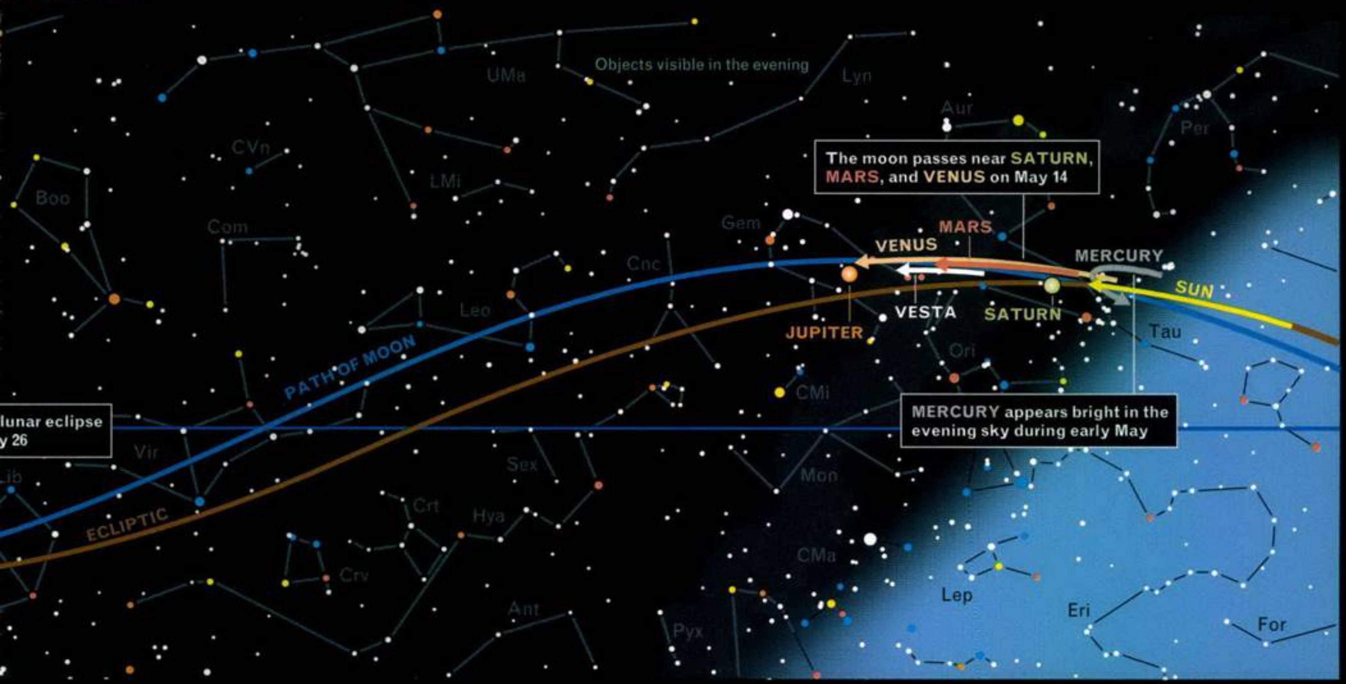


Jupiter's Moons

Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view in a telescope.



during the month.

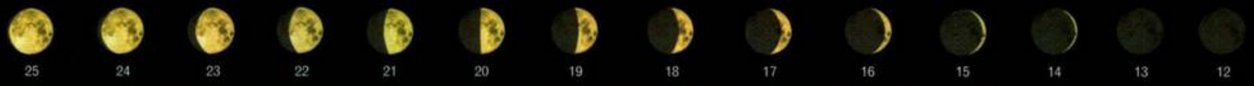

Objects visible in the evening
UMa
Lyn
Aur
Per
CVn
LMi
Boo
Com
Gem
MARS
VENUS
MERCURY
SUN
Cnc
VESTA
SATURN
JUPITER
Tau
Leo
Ori
PATH OF MOON
CMi
Vir
Lib
Sex
Mon
ECLIPTIC
Crt
Hya
CMa
Crv
Lep
Eri
For
Ant
Pyx

The moon passes near **SATURN**, **MARS**, and **VENUS** on May 14

MERCURY appears bright in the evening sky during early May

lunar eclipse
y 26

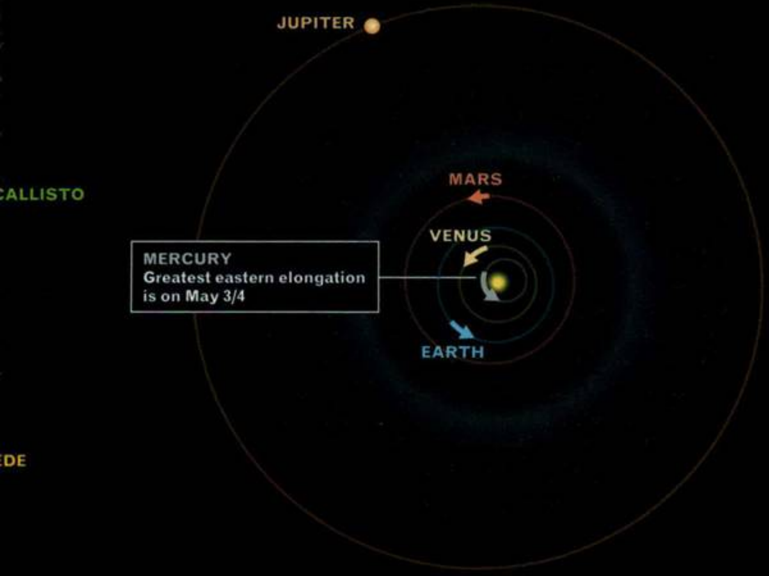
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.


25
24
23
22
21
20
19
18
17
16
15
14
13
12

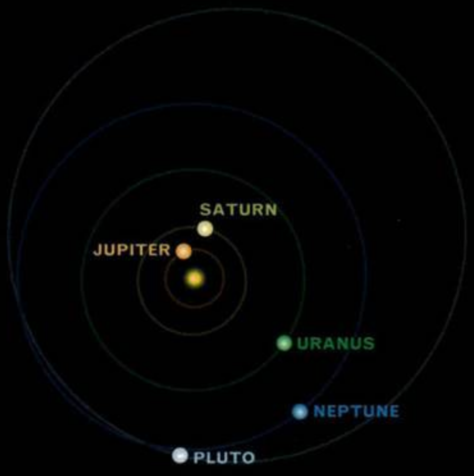
JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
May 15	May 15	May 15	May 15	May 15
–1.9	0.1	5.8	7.9	13.8
33.9"	16.6"	3.5"	2.3"	0.1"
99%	100%	100%	100%	100%
5.823	9.984	20.055	29.848	29.589
5.220	9.050	19.998	30.092	30.509
6h57.9m	4h56.2m	22h04.3m	20h53.5m	17h06.9m
23°00'	21°18'	–12°38'	–17°24'	–12°41'

The Planets in Their Orbits

Arrows and dots show planets' positions during the month.


JUPITER
CALLISTO
MARS
VENUS
EARTH
EDE

MERCURY
Greatest eastern elongation
is on May 3/4


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

Hunting with the Dogs

Whether you're searching for the heart of a king, stalking galaxies gone bad, or simply seeking a glorious star, Canes Venatici is the place to fix your gaze. One of the fathers of charting the stars, the Greek astronomer Hevelius, was the first to transport hunting dogs up into the sky in an effort to help nearby Boötes chase down Ursa Major the Great Bear.

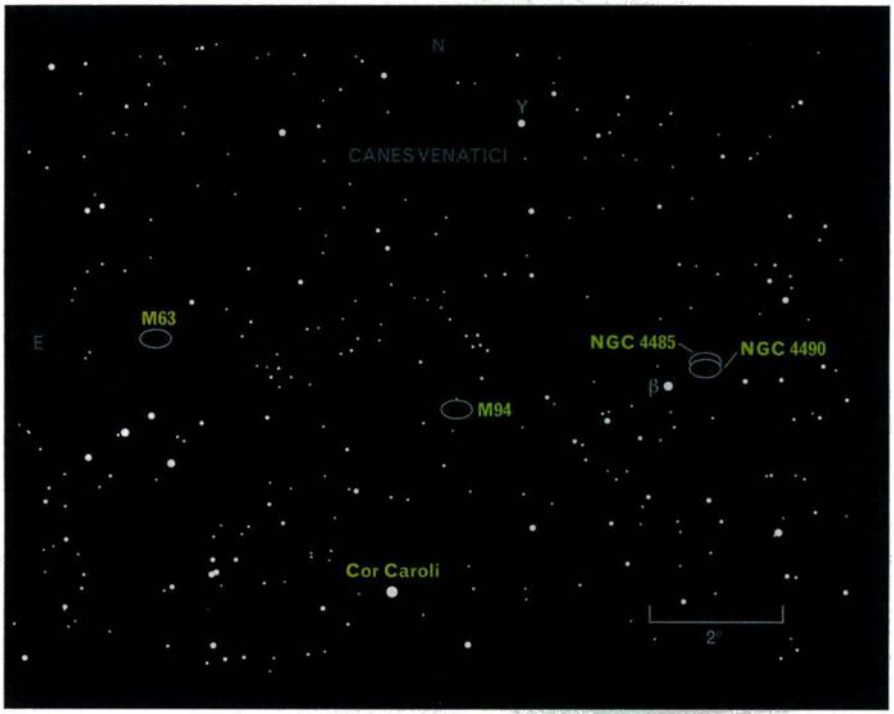
Once the sky has darkened, extend a line upward from the bright orange star Arcturus and also from the last handle star in the Big Dipper until the two lines intersect, forming a right angle. The bright star that shines at this intersection represents the heart of a royal. In honor of the executed King Charles I of England, this star was bestowed the lyrical name Cor Caroli.

This very heart of Canes Venatici is a double star well suited for small telescopes. The components are 20" apart, somewhat closer than the stars in summer's celebrated Albireo in Cygnus, and the pair's brightness is a near match to the Albireo suns. However, that's where the similarity ends. As the astronomers' inside joke goes, the color contrast here is subtle: while one star is white, the other is, well, white.

For color, head northward to a star whose name says it all — La Superba. At 5th magnitude, and as one of the finest "red" stars in the sky, it's easily visible in most finderscopes. Almost every red star belongs in the "variable" classification, and La Superba is no exception. On star charts you will find it as Y Canum Venaticorum. In a 4.5-inch scope you should see it in a distinct deep orange, made significantly more noticeable when you defocus the image slightly.

As it turns out, Y CVn was given its name not for its color, but for its distinctive spectrum. If you buy a two-dollar "rainbow sheet" diffraction grating from a hobby/science shop and place it in front of the eyepiece of an 8-inch scope, you should see that the star's spectrum has black marks — absorption lines — across the red end and a very weak blue end.

Among the delights of Canes Venatici, we head out to the bright spiral galaxy M94 (NGC 4736). At magnitude 8.2, this bright galaxy provides a decent challenge for suburbanites with a 4.5-inch scope. From dark country skies, its round fuzz protrudes more clearly from the sparse starfield. The bright nucleus suggests a supermassive black hole is driving starburst activity in the core. You'll need to boost up the power to separate out the starlike center from the bright inner glow.



Slightly farther out in space lies M63 (NGC 5055). Charles Messier's sharp-eyed colleague Pierre Méchain discovered both M94 and M63. A small scope reveals M63 as a distinct oval pointing toward a nearby 9.3-magnitude star. Its appearance in photographs led to the sobriquet "Sunflower Galaxy." This multi-armed spiral is home to hundreds of nebular cocoons, many of which may be found in our own Orion Nebula.

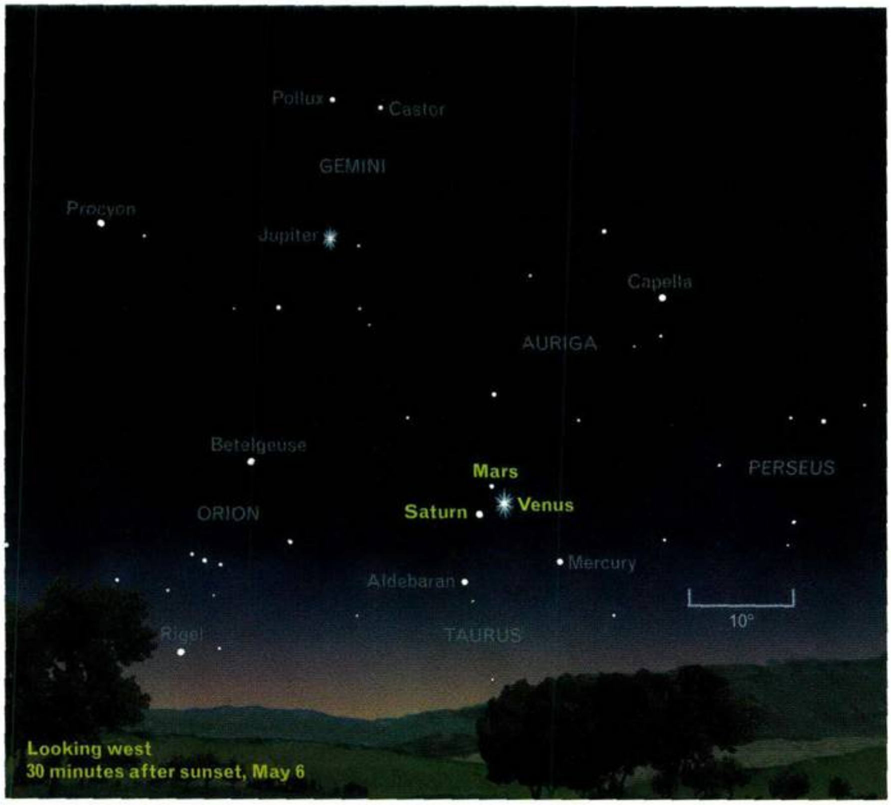
A hot target, the Sunflower Galaxy (M63) presents tightly-wrapped arms. Bill Iburg

A Walk on the Wild Side

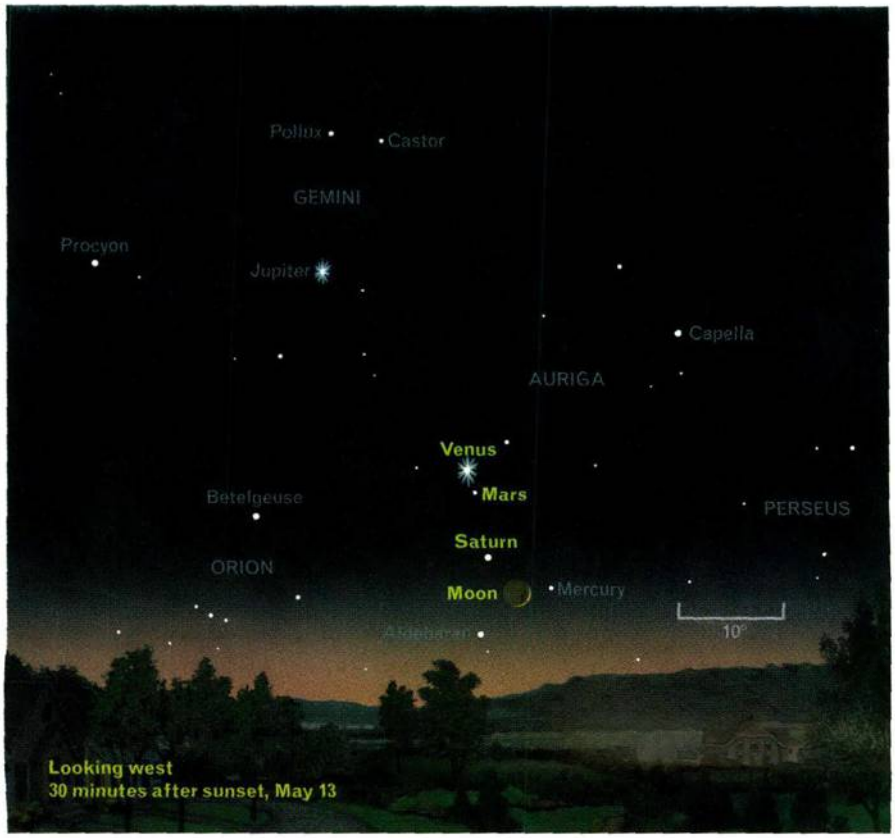
A visual stroll through Canes Venatici uncovers a share of oddballs. Amateurs find peculiar galaxies attractive because there's a chance of spotting something extraordinary versus the more common smooth elliptical or tilted spiral galaxies. Halton C. Arp compiled a list of 338 wonders in his 1966 *Atlas of Peculiar Galaxies*. Fortunately, the brightest ones are within reach of your average backyard telescopes, and a useful observer's guide is available on the web: http://members.aol.com/arpgalaxy/index.html.

Just west of Beta (β) CVn lies Arp 269, an interacting pair of galaxies. On star charts they are labeled as NGC 4485 and NGC 4490. At magnitude 9.8 and 11.9, respectively, the two curious structures should be just within reach of a 6-inch scope.

sky Show


Pollux
Castor
GEMINI
Procyon
Jupiter
Capella
AURIGA
Betelgeuse
Mars
PERSEUS
ORION
Saturn
Venus
Mercury
Aldebaran
10°
Rigel
TAURUS

Looking west
30 minutes after sunset, May 6


Pollux
Castor
GEMINI
Procyon
Jupiter
Capella
AURIGA
Venus
Mars
Betelgeuse
PERSEUS
Saturn
ORION
Moon
Mercury
10°
Aldebaran

Looking west
30 minutes after sunset, May 13

A Conjunction for the Ages

A veritable smorgasboard for the eyes draws attention to the western evening sky as the five classical planets — Mercury, Venus, Mars, Jupiter, and Saturn — spread before us along the ecliptic. This forms the finest planetary conjunction visible for more than 20 years. In May 2000 the planets were also grouped closely in the sky, but the event occurred in daylight. This year is a vastly different story.

Mercury will whet observers' appetites as it swings up from the sun to meet Saturn and Mars. But Venus, Saturn, and Mars provide the main feast as they lie within a 3° circle. And then there's dessert, too. Venus ends the month sitting snugly next to Jupiter — just 3° apart. The brilliant pair commands great attention.

The action begins on May 1 as **Mercury** attempts to catch up with **Venus**. The two lie 5.8° apart. Venus appears first after sunset, shining at magnitude –3.8 and easy to spot in bright twilight. As the sky darkens, look to the lower right of Venus for Mercury shining at magnitude 0.

Mercury won't catch up with Venus, though; the speedy little planet reaches its greatest elongation from the sun on May 4 and then falls back toward the horizon. Through a telescope, Mercury will show a 50-percent illuminated disk. The planet then fades as its orbital motion carries it to a point between Earth and the sun. At the same time each evening we'll observe Mercury at progressively lower altitudes. A telescopic view should reveal the planet's phase as its crescent shrinks.

Saturn and **Mars** become Venus's companions, each gradually rising out of the fading twilight. For a seven-day period from May 3 to 10, the three planets lie within a 5° circle. Venus is clearly the brightest, with Saturn next at magnitude 0.1, and then Mars at a relatively faint magnitude 1.6.

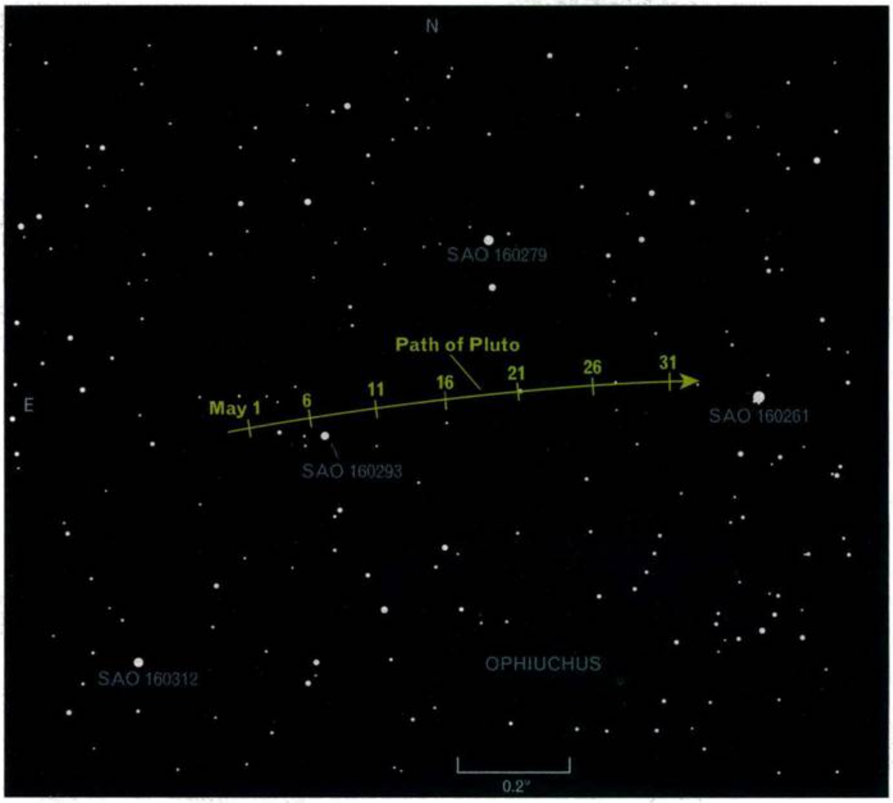
Watch nightly in the first week of May as Venus moves up to the Saturn-Mars pairing. On the evening of May 6 in the United States the newfound trio moves as close together as it will ever be — within a 2.8° circle that forms a beautiful triangle. Just 7° to the lower right lies Mercury. Meanwhile, Aldebaran, the bright star in Taurus, lies 6° to the lower left of Saturn. No finer planetary conjunction has graced our skies for decades.

During the four days following May 6, Mars and Venus move in formation with each other until May 10, when the two occupy the same telescopic field of view. Venus is three times the apparent size of Mars — it measures 12" across while Mars is a skimpy 4" across. The difference in brightness is also staggering, with Venus shining 5.5 magnitudes brighter than Mars. The Red Planet will be difficult to resolve in an unsteady atmosphere, a condition prevalent right after sunset.

A fine crescent moon adds to the celestial feast on May 13 when it lies just under six moon-widths (3°) to the left of Mercury, which will be faint and require optical aid to spot at about magnitude 2. For the best bet, try about 30 minutes before moonset along a clear, flat western horizon.

May 13 also represents the date during which all five planets are minimally separated. They are strung on a 33°-long arc along the ecliptic. With the planets lined up so nicely, it serves as an opportune time to both demonstrate and visualize how the solar system moves along a plane.

The moon skips along the ecliptic for the next night's encounter with our sister planet. On May 14 the crescent moon slides three moon-widths south of the "evening star," which itself stands 2.4° above Mars. On the same day, the moon occults Saturn, Mars, and Venus during daylight for limited regions of the planet. On the following night, May 15, the moon has jumped midway between Venus and **Jupiter**. The gas giant remains high in the sky among the stars of Gemini the Twins. Meanwhile, only 6.2° separate the moon and Jupiter. On the next evening, May 16, the moon lies 7° east of the giant planet. Asian and Australian observers will see Jupiter and the moon closer together. Venus continues to move along the ecliptic and on May 25 sits midway between Jupiter and Mars.



Jupiter is the only planet that retains enough elevation once the sky darkens to escape the observational plague of atmospheric turbulence. Early in May telescopic observers can still track some of the planet's myriad atmospheric features. In addition, the giant planet's moons will continue to stimulate satellite-junkies with big scopes, but beginners will also enjoy the jovian moons in small scopes. As the month ends, a final planetary conjunction lines up. The two brightest planets in the sky, Venus and Jupiter, stand a scant 4° apart. Jupiter shines at magnitude –1.9 and Venus has brightened to a stunning magnitude –3.9. This truly dazzling duo promises to catch everyone's attention, beginners and veteran skywatchers alike. Plus, it always makes for a great topic of conversation at evening barbecues and star parties, and an excellent opportunity for showing sidewalk passersby two satisfying planetary sights. Early next month the planets will continue to close in on each other even more, approaching less than 2° apart.

Mars has not left the scene entirely either. At the end of May the Red Planet crosses into Gemini and lies 2.3° northwest of Eta (η) Geminorum at the foot of the Twins. Saturn will be lost in the sun's glare. At the end of the month **Neptune** rises at midnight and stands in the middle of Capricornus. **Uranus** rises more than an hour later and spends its time in Aquarius.

Pluto is a month away from opposition and a fine challenge for 8-inch scopes or larger. Glowing faintly at magnitude 13.8, this speedy little orb is a challenging object to track down, but you can find it by using a detailed star chart that shows stars up to 14th magnitude. Pluto lies just west of the planetary nebula NGC 6309 in Ophiuchus and 3° north of Eta Ophiuchi. It's moving into a richer region of the Milky Way than in previous years, which, unfortunately, makes it all the more difficult to spot. But with consecutive nights of recording the starfield, a patient, keen-eyed observer should easily identify the elusive planet by its relative motion.

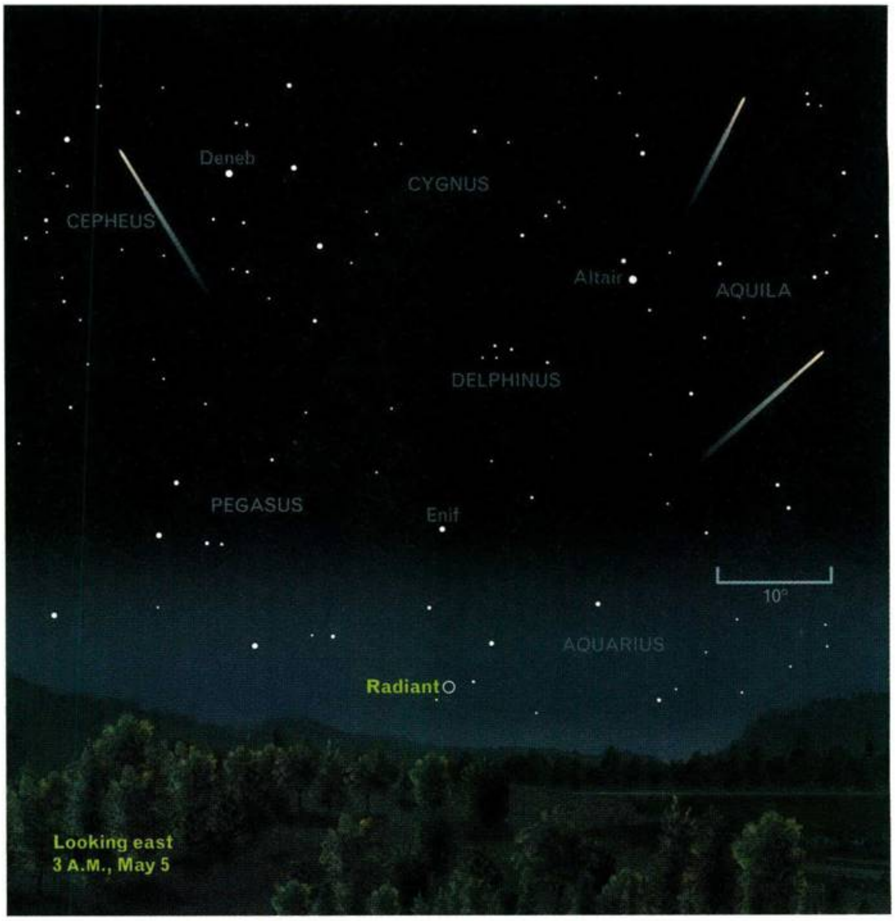
Meteors and Moons

Eta Aquarid Meteor Shower

This is the last reasonably predictable meteor shower before the August Perseids. The Eta Aquarids are challenging because the radiant, which lies near the Y-shaped water-jar asterism in Aquarius, rises only a couple of hours, at most, before sunrise. This limits observing to only the two hours before dawn. However, the zenithal hourly rate — the rate of meteors that would be seen if the radiant was overhead — is 60 meteors per hour.

The meteors from this shower are swift, averaging 41 miles per second (66 kps) as they collide with Earth's upper atmosphere. A crescent moon will interfere somewhat with observing, but considering the possibility of frequent bright streaks it is certainly worth waking up a little early on a few mornings.

The shower peak has been variable, sometimes arriving a day early. Various authorities estimate the peak to occur between May 4 and 6. The shower is above 50 percent of maximum for three days either side of these dates, so pick a clear morning and observe what happens. Meteor showers can surprise you — give it a shot.



Looking east
3 A.M., May 5

Penumbral Lunar Eclipse

A brief penumbral eclipse of the moon occurs on May 26. Although it's a minor eclipse, the show will present a slight darkening on the moon's southern edge may appear for observers in Australia and New Zealand. Most of North America will be able to view the eclipse, which occurs in the morning as the moon sets and the sun rises. It will take a keen eye to discern this slight dimming of our lunar companion.

Jupiter's Satellites

The next few weeks mark your last opportunity to observe Jupiter's satellites until late August, when the giant planet reappears in the morning sky. In addition to the rare Callisto events noted in the table to the left, the other three Galilean satellites put on a monthly show.

Individual events occur often. With any telescope, you can have fun plotting the relative positions of the four satellites to the disk of Jupiter.

The last chance to glimpse the rare occultations, transits, and eclipses of Jupiter's fourth large moon, Callisto, occur this month. During Jupiter's 12-year orbit around the sun, only two series of eclipses involving Callisto occur. The current series began last September and continues until September 2004, and only 66 eclipses will occur in this time. The events listed here are given in Universal Time (Greenwich Mean Time) and Eastern Standard Time. Events that occur on either side of midnight are shown twice (*), since the date changes for observers in Europe or the United States of America. IV = Callisto; Tr = Transit; I = Ingress; E = Egress; Oc = Occultation; Sh = Shadow Transit; Ec = Eclipse; D = Disappearance; R = Reappearance. Not all events are visible from the United States.

Callisto Events for May 2002

	UT	EDT	
May 2	14:02	9:02 A.M.	IV.Oc.D.
	17:25	12:25 P.M.	IV.Oc.R.
		7:30 P.M.	IV.Ec.D.
		11:23 P.M.	IV.Ec.R.
May 3	00:30		IV.Ec.D.*
	4:23		IV.Ec.R.*
May 10		8:40 P.M.	IV.Tr.I.
May 11	01:40		IV.Tr.I.*
	05:06	0:06 A.M.	IV.Tr.E
	11:14	6:14 A.M.	IV.Sh.I.
	15:05	10:05 A.M.	IV.Sh.E.
May 19	09:48	4:48 A.M.	IV.Oc.D.
	13:23	8:23 A.M.	IV.Oc.R.
May 27	21:37	4:37 P.M.	IV.Tr.I.
		8:15 P.M.	IV.Tr.E
May 28	01:15		IV.Tr.E*
	05:15	0:15 A.M.	IV.Sh.I.
	09:14	4:14 A.M.	IV.Sh.E.

LINEAR WM1: An Evening Farewell

Comet LINEAR WM1 entertained even the unaided eyes of observers back in December and January. Now that it has sprayed a fan of dust and gas in the inner solar system, WM1 is retreating out to the cold depths of space. It's your last chance to catch the comet in an 8-inch scope.

This dirty snowball is well placed in the late evening sky for the first half of the month, while the pesky light of the moon stays out of the way. LINEAR WM1 climbs ever higher into Hercules, over to the right of the bright blue-white star Vega, rising in the northeast.

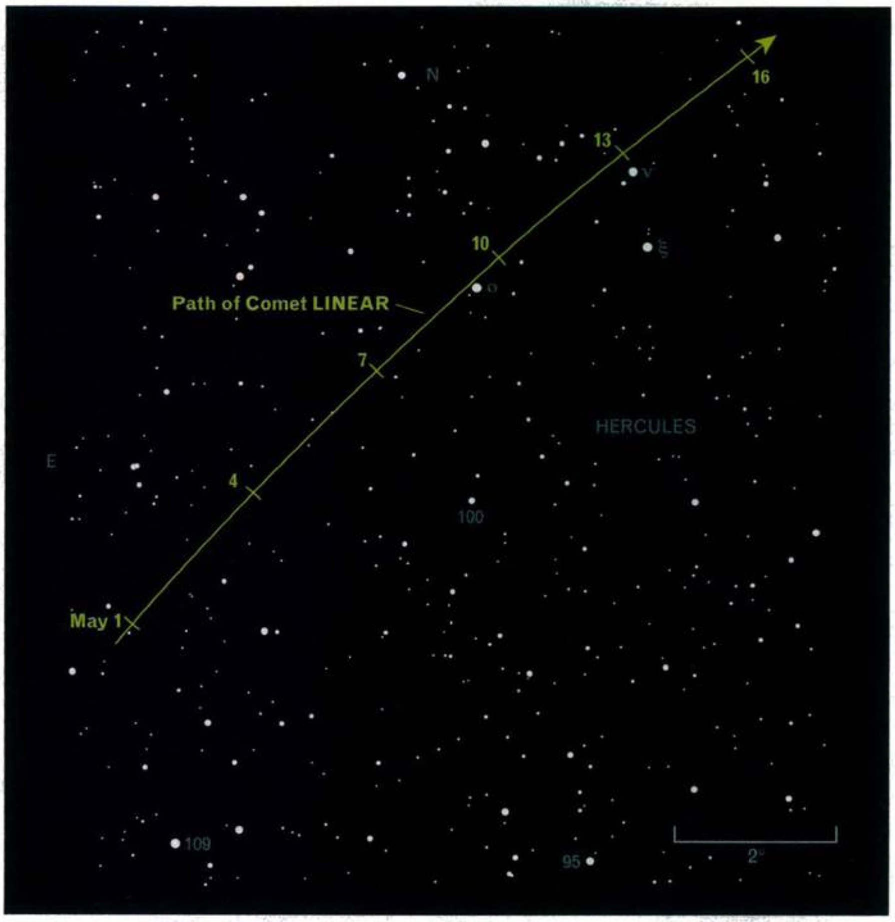
Pons-Winnecke Passes Perihelion

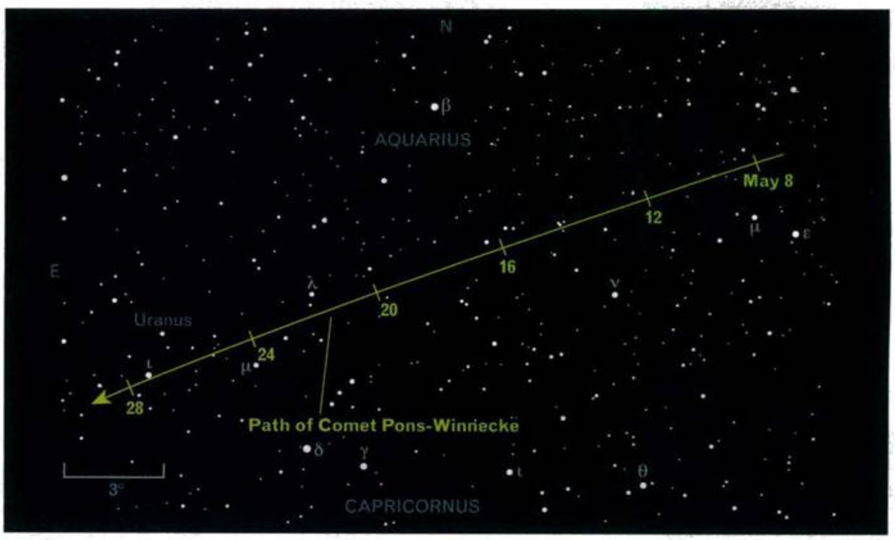
Comets typically reach their peak brightness when they are nearest the sun. If they're in view of Earth when they reach this point, called perihelion, we see them at their best. Pons-Winnecke should crest into the 10th-magnitude range, which means it won't be quite as bright as many Messier objects, so you'll need to observe under dark country skies.

Because the comet makes a morning showing, the best window of observation occurs between May 10 and 24. You can find it down in the Capricornus-Aquarius region, passing a few degrees north of M72 and M73, and south of Uranus.

To get a decent view of both Pons-Winnecke and LINEAR WM1, you'll have to push the magnification up past 100x in order to darken the field and make each fuzzball big enough to see. Then move up to 200x or more to get a better look at how the sunward edge is more sharply defined. This bow-shock edge forms from the solar wind blowing the dust outward.

Pons-Winnecke also goes by the prefix designation 7P. The P stands for periodic, and the 7 means that it was the seventh comet ever detected and recorded.





Asteroids

There may be no bright asteroids to see this month, but there are always plenty of dim ones for those who seek a challenge. Finder charts are available on the website of the British Astronomical Association Asteroids Section: check http://yan.open.ac.uk/~ajh47/arps.htm for the best ones. ■

Martin Ratcliffe is President of the International Planetarium Society Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

ASTELE 203EL
MAKSUTOV-CASSEGRAIN TELESCOPE
MADE IN RUSSIA BY LOMO
MULTI-COATED OPTICS
f/10
f=2028.2
D=203

RUSSIAN-MADE

TELESCOPES

New Maksutov-style scopes feature portability and Russian engineering.

Text by Phil Harrington
Photos by Bill Zuback

ASTELE 102 MN
Maksutov-Newtonian

The largest solid telescope mirror ever made is the creation of LOMO, Russia's largest manufacturer of telescopes and optical instruments. Established in St. Petersburg in 1914, LOMO — Leningradskoe Optiko Mechanichesckoe Objedinenie — (translated as "Leningrad Optical and Mechanical Enterprise") currently produces a wide variety of optical equipment, ranging from surgical microscopes to telescopes.

LOMO incorporates the Maksutov design of catadioptric instruments, which — like the Schmidt-Cassegrain telescopes — combines features of refractors and reflectors. A LOMO's distinctive trait is its "deep-dish" front corrector plate set inside the spherical primary mirror's radius of curvature. Light passes

Left: The sturdy Astele 203EL features an 8-inch aperture; Upper right: In tests, the Astele 102MN showed no sign of spherical aberration; Lower right: Astrophotographers will appreciate the 102MN's rugged mount.

through the corrector plate to the primary, then to a convex secondary mirror — a design known as a Maksutov-Cassegrain. In these, the secondary mirror returns the light toward the primary, where it passes through a central hole out to the eyepiece at the back of the tube. This layout socks a long focal length into the shortest tube possible.

A Maksutov telescope may also be constructed using a Newtonian configuration where the secondary mirror tilts at 45°, passing light through a hole in the side of the telescope's tube to the waiting eyepiece. The greatest advantage of the Maksutov-Newtonian over the traditional Newtonian is that its short focal length (and wide field of view) produces very little coma or astigmatism.

Six Astele Maksutov-Cassegrain instruments range from 2.8-inch to 8-inch apertures, while four Maksutov-Newtonians are manufactured in the 4-inch to 8-inch aperture range. I evaluated four of the Maksutov-Cassegrain styles as well as one of the Maksutov-Newtonian designs.

The compact Astele 70 features either a black tube or a decorative blue-and-white star-map tube and comes with a 1¼" star diagonal, 25mm Plössl eyepiece, and a carrying case. Either style includes a small mounting block for attaching the telescope to a photographic tripod. Instead of a finderscope, LOMO supplies a pair of molded-plastic sighting rings on the tube, adequate only for pointing in the general vicinity of a target.

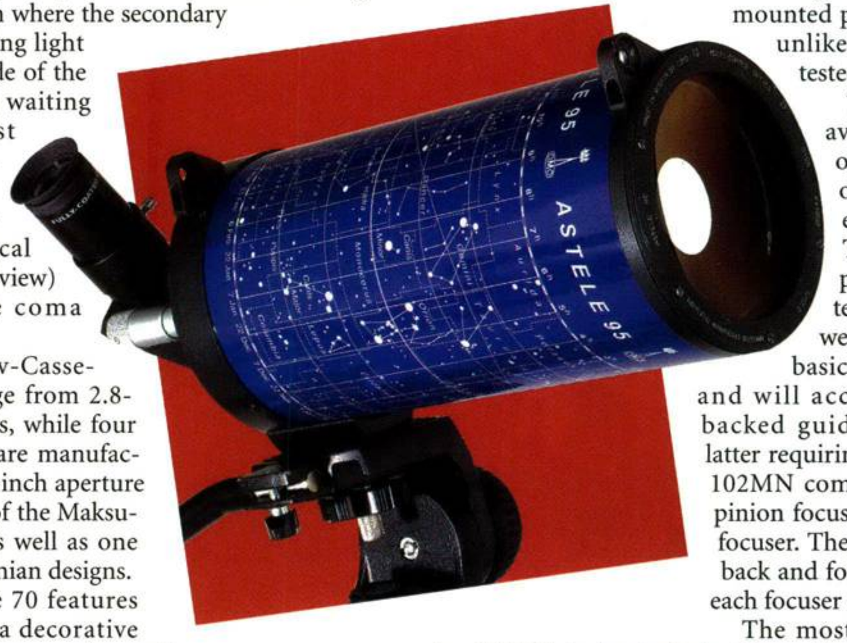
A large focus knob on the side of the Astele 70 moves the primary mirror back and forth internally — a system common to the larger Astele Maksutov-Cassegrains as well as many other catadioptric telescopes. If the primary tilt shifts while turning the focusing knob, you'll see a noticeable "jump" in the image.

The tube of the Astele 95 is also decorated with a white-on-blue star map. The set-up includes a 1¼" star diagonal and 25mm Plössl eyepiece, and is available with a German equatorial mount and tripod, or as an unmounted spotting scope. The right ascension and declination axes have manual slow-motion controls; a battery-driven clock drive is sold optionally. (The internal focusing on this model did not exhibit the image shift as seen in the Astele 70.) The equatorially mounted Astele 95 includes an adjustable 5x finderscope. Like the Astele 70, the unmounted Astele 95 is aimed through a pair of externally mounted plastic sighting rings; unlike the Astele 70, these tested dead-on.

The Astele 102MN is available as a separate optical tube assembly or with a German equatorial mounting. The mount easily supports the 11-pound telescope tube. It works well for observers doing basic lunar photography, and will accommodate piggybacked guided exposures (the latter requiring a clock drive). The 102MN comes with a rack-and-pinion focuser as well as a helical focuser. These are easily swapped back and forth and let users turn each focuser relative to the tube.

The most unusual feature of the 102MN is the built-in 30mm finderscope attached to the secondary mirror mount. Twist the secondary's protruding housing in one direction and light from the primary mirror passes into the eyepiece; turn the housing 180°, and light entering the finder's objective gets diverted into the eyepiece instead. It's a great idea, but one that takes some getting used to.

One challenge common to all right-angle finderscopes is the difficulty in telling exactly where the telescope is aimed, since the observer is not looking along the telescope's line of sight, but at a 9° angle. Adding a one-power unity finder, such as a Telrad, solves this problem. A second problem unique to Astele Maksutov-Newtonians is that the finderscope's magnification depends on the eyepiece inserted into



A white-on-blue star map that adorns the exterior of the Astele 95's optical tube provides a quick reference for observers.

LOMO FACT TABLE

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e-mail: lomoamerica@dis.net
http://www.lomoamerica.com/

Astele 70
List price: $300

Astele 95
List price: $500

Astele 102MN
List price: $800

Astele 133.5
List price: $1,300

Astele 203EL
List price: $3,000

(Go to www.astronomy.com for complete telescope specifications.)

the telescope's focuser; the supplied 25mm Plössl eyepiece produces 8x and a 5° field of view. Another drawback is that by using a standard eyepiece in the finder, there are no crosshairs. Finally, and perhaps most importantly, the finderscope's large housing inevitably diminishes image contrast.

Nearly all reflectors contain secondary mirrors whose mountings block a percentage of the telescope's aperture. While this does not dim the view appreciably, it weakens image contrast in proportion to the size of the telescope's diameter. Many Newtonians have central obstructions in the 15-to-20 percent range, while Schmidt-Cassegrain telescopes average 30 percent. The Astele 102MN assembly creates a 41 percent obstruction. The larger Astele Maksutov-Newtonians are less affected, although their central obstructions still average around 30 percent.

ASTELE 133.5
LOMO
ASTELE 133.5 EL

LOMO's Astele 133.5 Maksutov-Cassegrain delivers clean images of close-set star pairs and offers sharp planetary views.

The 5.25-inch Astele 133.5 and 8-inch Astele 203EL are designed very similarly to other Cassegrain-based catadioptric telescopes. Negligable image shift occurs with either instrument. Standard equipment for each includes a 1¼" focuser and star diagonal, a 25mm Plössl eyepiece, and an 8x40 right-angle finderscope. While the finder worked well, its mounting bracket was not parallel to Astele 203's optical tube, making it impossible to align the finder properly. The Astele 133.5's finder mount, though of similar design, worked properly.

These models are sold on either a German equatorial mount or on a fork-style equatorial mount; I tested the latter type for both. Each includes manual slow-motion control knobs for adjusting aim in right ascension and declination, as well as an electric clock drive motor on the right ascension axis. A hand-held controller box houses the 9-volt battery that powers the drive (not evaluated). Both of these fork mount bases fit LOMO or Meade equatorial wedges.

None of the fork-mounted Astele instruments come with a wedge or tripod. LOMO sells these and other accessories — including dew caps that thread onto the fronts of the telescope tubes, eyepieces, and clock drives — separately. The Astele 95 and larger Maksutov-Cassegrains also accept standard Meade- and Celestron-threaded accessories.

Maksutovs cool more slowly than other designs because of their closed tubes and thick corrector plates. Once acclimated to the ambient outdoor temperature, however, the Astele 95, 133.5, and 203EL performed quite well, producing sharp star images with good resolution. I easily split Epsilon Lyrae, the famous Double-Double in Lyra, using my 7mm Pentax XL eyepiece through the 95 (171x), 133.5 (190x), and 203EL (290x). All three cleanly displayed two close-set pairs of stars surrounded by nicely delineated diffraction rings. Though difficult to see any surface detail because of a planet-wide dust storm last summer, Mars also showed a sharp disk with vague markings.

Both the Astele 95 and 133.5 passed the star test flawlessly, but the 203EL showed a small amount of spherical aberration. The flaw was not enough to adversely affect performance, except on the critical objects. The Astele 70 suffered from quite a bit of spherical aberration, however. The 102MN showed no sign of spherical aberration — indeed, star images were extremely sharp and snapped into focus. Binary stars, such as the Double-Double, split easily, while many open star clusters in Scorpius, Scutum, and Cygnus resolved cleanly. The vague surface markings on Mars were a bit more so through the 102MN than through my 4-inch Vixen achromatic refractor at about the same magnification. Bright nebulae such as M8 and M17 and galaxies like M51 were also a bit tougher to discern through the 102MN than through the refractor — no doubt because of the large central obstruction.

LOMO's Astele Maksutovs show great signs of promise with a well-conceived and executed basic design. Observers looking for a compact instrument would favor the Astele 95 or 133.5. The Astele 203EL was also a good performer, though not quite as sharp. I enjoyed the extreme portability of the Astele 70, which is perfect for anyone who likes to hike to his or her favorite observing site — but the likelihood of spherical aberration restricts it to lower magnifications.

Finally, the Astele 102MN yields sharp star images and pleasing views of double stars and star clusters, although the large central obstruction dilutes the view of low-contrast objects, such as bright nebulae, some galaxies, and subtle planetary detail.

Phil Harrington regularly tests equipment for Astronomy. *Visit his website at http://www.philharrington.net.*

Canes Venatici

If you're on the prowl for bright, nearby galaxies, you won't go wrong exploring the territory guarded by the Hunting Dogs.

by Tom Polakis

To most backyard observers, spring evenings conjure warm thoughts of galaxy hunting. Understandably, most of that focus centers on the constellations Virgo and Coma Berenices, home to the nearest large galaxy cluster. Point a telescope at random in this area and you're likely to see multiple galaxies swimming in the field of view.

Although not as famous as its southern neighbors, the nondescript constellation Canes Venatici the Hunting Dogs holds its own as a haven for galaxies. Sandwiched between Coma Berenices and the bright stars of the Big Dipper in Ursa Major, Canes Venatici lies nearly 90° from the plane of our galaxy. That makes it predictably star poor and galaxy rich. The best news: Many of these galaxies appear large and bright because they dwell in the nearby reaches of the Local Supercluster.

Canes Venatici contains two moderately bright naked-eye stars. **Alpha (α) Canum Venaticorum**, also known as Cor Caroli, makes a fine double star for small telescopes that can be split easily at 20x. The 2.9-magnitude primary star lies 110 light-years from the sun and shines 60 times brighter. The 5.5-magnitude secondary is a foreground star that just happens to be along the same line of sight. Similar in brightness to the sun, it lies 80 light-years away. At one-third that distance, 4th-magnitude Beta (β) Canum Venaticorum ranks as the nearest bright star in the constellation.

The prominent stars of Ursa Major make a convenient starting point for locating galaxies in Canes Venatici. For example, **M106** (NGC 4258) in the northwestern corner of the constellation forms a triangle with Gamma (γ) and Chi (χ) Ursae Majoris. This spiral galaxy shows a bright core surrounded by an oval haze extending 15' by 5'. An elongated inner disk one-third that size lies immediately around the center. A mottled texture and glimpses of spiral structure become apparent in apertures larger than 10 inches. The strikingly linear northern arm appears more pronounced, while the symmetrically placed southern arm looks more diffuse and requires patience to see. M106 lies 23 million light-years from Earth.

At twice that distance, and right on the western border of Canes Venatici, you'll find one of the constellation's many classic edge-on galaxies. The high surface brightness of **NGC 4111** permits viewing at high magnification. The galaxy appears only 4' long and one-fifth as wide. Look for a brilliant nucleus surrounded by a bright oval region, from which faint wings radiate. The featureless surface of NGC 4111 shows no sign of a dust lane. A 13-inch scope shows at least five fainter galaxies in the same field.

The small spiral galaxy **NGC 4143** lies less than 1° to the southeast. It stands at the southern edge of the little-studied Ursa Major galaxy cluster. This gathering of about 80 galaxies is one of three prominent galaxy clusters within 150 million light-years of Earth, but the other two — in Virgo and Fornax — get all the attention. Observers practically ignore the one in Ursa Major because it lacks a concentrated core and lies in a confusing array of non-members. Although NGC 4143 is plenty bright, it shows little more than a bright center

Artwork from *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

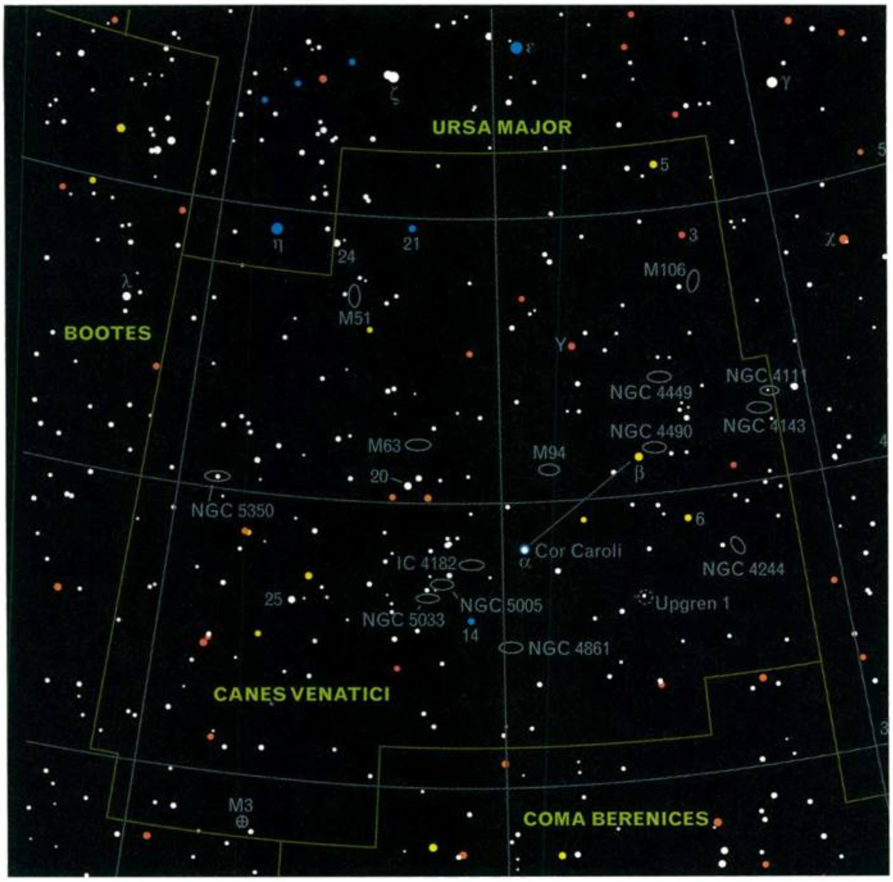
Tony and Daphne Hallas

and a faint, oval halo thanks to a diminutive size of just 2' by 1'.

The barred spiral galaxy **NGC 4490** lies just northwest of Beta Canum Venaticorum, in the same low-power field. It appears as a mottled oval halo 5' across that envelops a bright core. You'll need a large scope to spot its thick spiral arms. Look just north of the galaxy's western end for the fainter glow of its companion, NGC 4485. A mere 25,000 light-years separates this interacting pair.

Pan 2.5° north to locate the irregular galaxy **NGC 4449**. Classified as "magellanic" because it appears similar to the Large Magellanic Cloud, it's actually twice as big as the LMC and about 85 times farther away. An 8-inch instrument reveals a well concentrated nucleus surrounded by a 4' by 2' mist. With an aperture of 12 inches, the galaxy shows an irregular texture. Even larger scopes bring out a well-defined knot south of the core and a more diffuse one at the northern edge.

The spectacular edge-on spiral galaxy **NGC 4244** lies 2° southwest of 5th-magnitude 6 Canum Venaticorum and some 12 million light-years from Earth. A 6-inch telescope shows the galaxy — whose disk inclines 5° to our line of sight — to be 15' long and less than 2' wide. The core appears only slightly brighter and quite elongated. To the northeast, the galaxy fades gradually into a broad haze. On the opposite side of the core, the surface seems more mottled and irregular.



Most observers are surprised to see an open cluster in Canes Venatici, so far from the Milky Way. It's not much of a cluster, however. **Upgren 1** forms an equilateral triangle with Alpha and Beta Canum Venaticorum and lies 450 light-years from Earth. An 11x80mm finderscope reveals a tiny clump of stars. Through a small scope at 30x, this old cluster appears as a group of seven white stars brighter than 10th magnitude scattered across 15'.

The brightest galaxy in Canes Venatici also forms a triangle with Alpha and Beta, but on the opposite side from Upgren 1. **M94** (NGC 4736) proves impressive in terms of sheer brightness — making it easy to find in small refractors from mediocre sites — although structure is hard to come by. Moderate telescopes show a tiny nucleus that appears overexposed surrounded by a sharp, bright disk measuring 30" across that *The Hubble Atlas of Galaxies* describes as "devoid of spiral structure." A much fainter halo some 5' long and slightly non-circular surrounds this disk. A 16-inch scope brings out broad spiral arms in this halo that wrap fully around the

Deep-Sky Objects in Canes Venatici

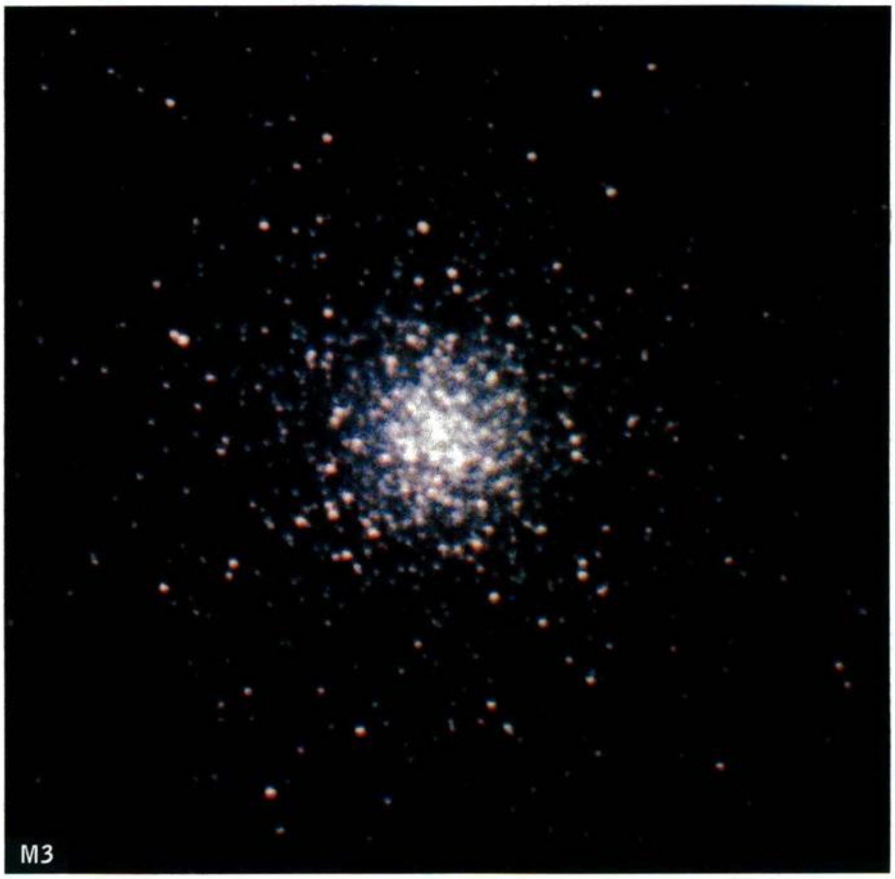
Object	R. A. (2000.0)	Dec.	Mag.	Size/Sep.	Type	Notes
NGC 4111	12h07.1m	43°04'	10.7	4.4' by 0.9'	Gal	SA(r)0
NGC 4143	12h09.6m	42°32'	10.7	2.9' by 1.9'	Gal	SAB(s)0
NGC 4244	12h17.5m	37°49'	10.4	17.0' by 2.2'	Gal	SA(s)cd
M106 (NGC 4258)	12h19.0m	47°18'	8.4	20.0' by 8.4'	Gal	SAB(s)bc
NGC 4449	12h28.2m	44°06'	9.6	5.5' by 4.1'	Gal	IBm
NGC 4490	12h30.6m	41°38'	9.8	6.4' by 3.3'	Gal	SB(s)d pec
Upgren 1	12h35.0m	36°23'	—	14'	OC	
M94 (NGC 4736)	12h50.9m	41°07'	8.2	13.0' by 11.0'	Gal	(R)SA(r)ab
Alpha Canum Venaticorum	12h56.0m	38°19'	2.9/5.5	19"	Dbl	Cor Coroli
NGC 4861	12h59.0m	34°52'	12.3	4.1' by 1.6'	Gal	SB(s)m
IC 4182	13h05.8m	37°36'	12.5	6.4' by 5.5'	Gal	SA(s)m
NGC 5005	13h10.9m	37°03'	9.8	5.8' by 2.8'	Gal	SAB(rs)bc
NGC 5033	13h13.4m	36°36'	10.2	10.5' by 5.1'	Gal	SA(s)c
M63 (NGC 5055)	13h15.8m	42°02'	8.6	13.5' by 8.3'	Gal	SA(rs)bc
M51 (NGC 5194)	13h29.9m	47°12'	8.4	8.2' by 6.9'	Gal	SA(s)bc
M3 (NGC 5272)	13h42.2m	28°23'	5.9	16.2'	GC	
NGC 5350	13h53.4m	40°22'	11.3	3.1' by 2.5'	Gal	SB(r)b

Object: Designation in Messier, NGC, or other catalog. **R. A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes; separation in arcseconds. **Notes:** Hubble type for galaxies.

disk. In long-exposure photographs, an outer ring more than 4' from the galaxy's center becomes apparent.

About 3.5° south of Alpha Canum Venaticorum lies the small galaxy **NGC 4861**. The galaxy itself glows only faintly in a 10-inch telescope at a good site, but an impressive region of ionized hydrogen makes viewing it worthwhile. A 13th-magnitude foreground star lies at the northern end of the galaxy's 3' by 1' haze, while the giant hydrogen cloud appears at the southern end. With a nebula filter in place, the gas cloud remains but the rest of the galaxy nearly disappears. The hydrogen region, which appears about 20" across through the eyepiece, actually spans roughly 5,000 light-years.

A pan 3° to the north-northeast will bring the spiral galaxy **IC 4182** into view. In 1937, a supernova here rose to magnitude 8.7, making it the second brightest of the 20th century. Unfortunately, IC 4182 proves unspectacular in the eyepiece. You'll need a 10-inch telescope to see it at all, and even in my 20-inch at a dark site, it appears only as a circular patch 4' across with an irregularly bright surface.


M3

Klaus Brasch

The Hunting Dogs

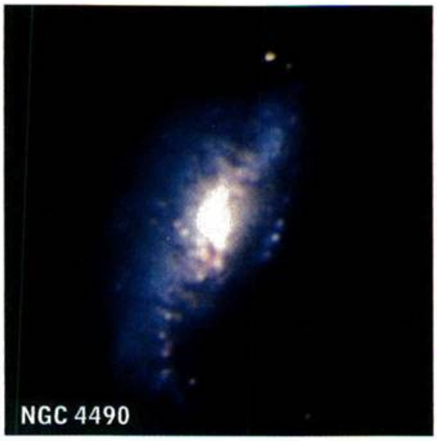
"The dusky night rides down the sky And ushers in the morn:
The hounds all join in glorious cry, The huntsman winds his horn;
And a-hunting we will go."
A-Hunting We Will Go, *Henry Fielding (1707–1754)*

Man's best friend they may be, but dogs obviously rate high among the mythological figures that rule the sky. No fewer than four canines romp across the heavens: Canis Major the Big Dog, Canis Minor the Little Dog, and the hunting dogs known as Canes Venatici. While the first two were invented by the ancients to accompany their master, Orion the Hunter, Canes Venatici are mere pups. The 17th-century Polish astronomer Johannes Hevelius invented the constellation by carving it out of Ursa Major the Great Bear, where it had been since the time of Ptolemy.

Hevelius depicted the dogs on a leash held by Boötes the Herdsman, or Bear Driver. Boötes' job was to watch the bear and make sure it kept circling the pole. Hevelius felt that the dogs would make the job easier.

The dogs — named Asterion and Chara — also play a role in the story of Icarius. This wealthy landowner planted immense fields of grapes, and he showed them to Bacchus when that god visited. Impressed by the hospitality, Bacchus explained how to make wine. Icarius held a festival where the partygoers all drank too much and awoke with hangovers. They decided Icarius had tried to poison them, and in retribution killed and dumped him in a ditch. When the dogs found their master, they leapt in the ditch to die with him.

The name of the brightest star in Canes Venatici, Cor Caroli, means "Heart of Charles." Legend has it that Edmond Halley named it for King Charles II. Supposedly, the star shone especially bright on May 29, 1660, when the king returned from his coronation. — *Richard Talcott*


NGC 4490

Jack Newton

NGC 5350

Preston Scott Justis

M106

James R. Foster

A much brighter spiral lies a bit more than 1° to the east-southeast. **NGC 5005** shows a strongly elongated glow about 5' long that concentrates to a bright stellar core. A 1'-wide oval disk of intermediate brightness surrounds the nucleus. A 16-inch scope shows patchy detail in the outer region that marks the thin spiral arms. The 9th-magnitude star 12' west of the galaxy belongs to the Milky Way.

Next pan just 40' to the southeast to find **NGC 5033**, a galaxy that measures 3' by 1'. It appears elongated north-south and grows gradually brighter to a small nucleus. A 13th-magnitude foreground star shines at the galaxy's northern end. Dark skies aid in bringing out the faint spiral arms that wrap loosely around the inner glow. They show up best just to the east and west of the galaxy's center.

Looking for these faint galaxies helps tune your observing skills to see more detail in brighter objects. **M63** (NGC 5055), the Sunflower Galaxy, reveals a wealth of detail to the careful observer. An oval halo 3' long surrounds this galaxy's bright stellar nucleus. In a 10-inch telescope, the halo shows clumpy structure. Outside this central bright region, a fainter haze fades gradually to the background sky. A larger scope reveals subtle hints of the multitude of spiral arms that populate the periphery and give the galaxy its sunflower nickname. M63 lies 24 million light-years away and gets classified as a "flocculent" spiral, meaning it possesses only patchy, localized spiral structure.

Nearly everyone who has pointed a telescope at the sky has admired the spiral structure of **M51** (NGC 5194), the Whirlpool Galaxy. In 1845 Lord Rosse used his 72-inch reflector to see spiral structure in M51 — the first observation of its kind.

Yet M51's biggest claim to fame is the presence of its companion galaxy, NGC 5195. Computer models indicate that the companion passed very close to the edge of M51's disk some 70 million years ago and then plunged through the galaxy's plane. NGC 5195 now lies some distance behind the plane of M51's disk. Although photographs and even large telescopes appear to show a connecting arm between the two galaxies, this bridge is an illusion. Distance estimates place M51 some 27 million light-years away, though this figure remains a topic of debate.

M51 looks magnificent in any size telescope. The spiral arms become visible in scopes as small as 8 inches, though even smaller instruments will reveal the arms as a brightening around the halo's rim. And in a 12-inch telescope, they become very apparent and show patchy detail. They don't appear as continuous arcs as much as a series of connected lines. An attentive viewer with a large telescope may notice the thin, dark dust lanes that follow the inner edges of the spiral arms. The apparent connecting arm should begin to show up in a 10-inch scope at a dark site. Field stars scatter across the face of M51, with the brightest masquerading as a supernova in a spiral arm southwest of the core. Although NGC 5195 appears smaller and fainter overall, its core actually glows brighter than that of the larger spiral.

Toward the eastern edge of Canes Venatici lies a grouping of galaxies highlighted by the barred spiral **NGC 5350**. Find it by forming an equilateral triangle with the bright stars Gamma and Lambda (λ) Boötis to the east. The tiny NGC 5350 measures only 2' across and has a subtle bar that traverses the center. A 6th-magnitude yellow star lies only 3' southwest of the galaxy. An interacting pair of galaxies, NGCs 5353 and 5354, appears less than 5' south of NGC 5350. Just 50,000 light-years separate this pair. NGC 5353 shows up as 1.5' across and circular, while NGC 5354 spans 3' by 1.5' and has a bright nucleus. These three galaxies join with two others to form a compact galaxy group that appears as number 68 in a catalog of these groups compiled by Paul Hickson.

Let's round out our tour with a rarity for a region located so far from the galactic center. The globular cluster **M3** (NGC 5272) lies in far southern Canes Venatici, about midway between Cor Caroli and Arcturus in Boötes. This globular shines with the light of more than 300,000 suns from a distance of nearly 35,000 light-years. Its angular size implies a physical diameter of roughly 150 light-years. Under good conditions, you might glimpse M3 without optical aid.

The cluster's most luminous stars glow at magnitude 12.7, which means the cluster will appear splashy even in a small telescope. A 6-inch scope shows M3 as a grainy sphere with a very bright center and many stars resolved around the perimeter. In a 13-inch at 200x, the globular shimmers with hundreds of resolved stars out to a diameter of nearly 15'. The view just keeps improving with increasing aperture — a 20-inch provides a dizzying array of pinpoints that resolve across the center. Keep in mind as you observe M3 that if the sun were placed at this distance, it would be an invisible 20th-magnitude star.

Tom Polakis is an aerospace engineer who lives in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and photography.

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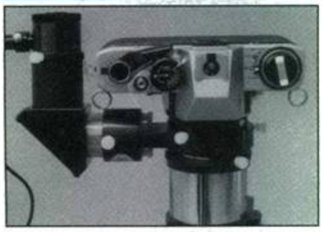

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For 8" Schmidt-Cassegrain telescopes choose the **LUMICON CASSEGRAIN EASY GUIDER™.** Includes multiple adjustments for easily finding and centering a guide star and for composing the picture. The included internal 50mm focal reducing lens delivers brighter f/6 photographic images and can be used visually with an optional adapter. The lens can be removed for f/10 photography. A 35mm camera adapter (specify camera) is included **$249**
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The king of off axis guiders is the **LUMICON GIANT EASY GUIDER™.** Made for Schmidt-Cassegrain telescopes of 10" through 16" diameter, the giant easy guider attaches to the large 3" rear threads of these scopes. Included is an 80mm diameter focal reducing lens capable of delivering f/7 to f/4 photographic speed. Replacing the included 35mm camera adapter (specify camera) with a 2" star diagonal turns the giant easy guider into a full aperture rich-field viewer **$395**
$1^{1/4}$" viewing adapter for rich-field ... **$25**

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MICON H-BE
ICON OIII
UMICON UHC
N DEEP-SKY

Lumicon Deep Sky Filters block light polluting mercury and sodium vapor lamp emissions while letting thru all other parts of the spectrum. Deep Sky Filters are most useful for astrophotography (both color & b&w plus CCD work. However, Deep Sky Filters are also useful visually, offering contrast gain for nebula, galaxies, star clusters and dusty comets.

1.25" Deep Sky Filter (fits most 1.25" eyepieces)	$99.50
48mm Deep Sky Filter (fits 2" eyepieces and Lumicon accessories)	$199.50
Visual Back Deep Sky Filter (fits in series on back threads of SCT'S)	$199.50
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*step rings for other sizes available.

Lumicon Ultra High Contrast Filters provide high-contrast views of all types of nebula. Best used with any telescope of f/6 or longer focal ratio. The Ultra High Contrast Filter is not for photography.

1.25" Ultra High Contrast Filter (fits most 1.25" eyepieces)	$99.50
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Visual Back Ultra High Contrast Filter (fits in series on back threads of SCT'S)	$199.50

Lumicon Oxygen III Get maximum contrast gain possible on planetary nebula and most emission nebula. Views of the Veil Nebula, the "Swan" the "Lagoon" and others with this filter are beyond words. The Lumicon Oxygen III Filter is for visual use only and is best suited for 6" and larger aperture telescopes with focal ratio of f/10 or faster.

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Visual Back Oxygen III Filter (fits in series on back threads of SCT'S)	$199.50

Lumicon Hydrogen Beta Filters were created to enhance a select number of low energy nebulae such as the elusive "Horsehead", the "Cocoon" & the California Nebula. In many instances the Hydrogen Beta filter is the **ONLY** way to see these nebulae. The H-Beta Filter is a visual filter only, and is best suited to 8" or larger aperture telescopes with focal ratios of f/5 or faster.

1.25" Hydrogen Beta Filter (fits most 1.25" eyepieces)	$99.50
48mm Hydrogen Beta Filter (fits 2" eyepieces and Lumicon accessories)	$199.50
Visual Back Hydrogen Beta Filter (fits in series on back threads of SCT'S)	$199.50

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Filters normally priced at $99.50	pay only $92.50
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Includes Computer ▪ Encoders ▪ Hardware

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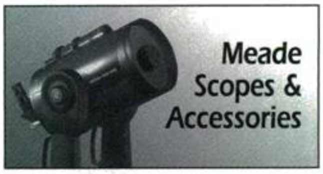
Our Featured Product!

Lumicon Multiple Filter Selector

The 1.25" Lumicon Multiple Filter Selector allows you to easily switch views between your Lumicon 1.25" Deep Sky, Oxygen III, UHC and H-Beta nebula filters. Five universally threaded slots allow you to use most 1.25" color planetary filters. Leave one slot open to compare views with and without filters. The filter slide has positive click stops for steady, smooth operation. The Lumicon MFS barrel is threaded for Barlow use for achieving focus with low profile, fast Newtonian telescope focusers. Threaded for camera T-mount use. $119.00 ($99.50 with purchase of 1.25" Lumicon filter).

Great National Brands



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Beginner's sky

Diary of a neophyte astronomer. By Jerry Burstein

I'll be the first to admit I don't always "keep at it." As a dad, though, I want to instill in my daughter the ethic of "don't be a quitter." Unfortunately, "do as I say — not as I do" more likely happens. And, as the winter months drag on, it becomes tougher and tougher to make ourselves go outside and enjoy the great hobby we discovered earlier in the year. The most beneficial inspiration is the surprising number of e-mails offering encouragement and suggestions.

I've found that many readers of all skill levels are eager to help "newbies" like me. And so I'd like to share some of the notes — and hope that it encourages you to not only "keep at it," but also to help others who get discouraged from time to time . . .

I'm a neophyte too. I also began with binoculars, telling myself that they were better than what Galileo had — but I found them wanting. So I bought a telescope because it was on sale (and I always wanted one). It came with a computer program and a software application that I promptly buried in a drawer. I just wanted an expert to help me orient myself enough to learn the rest.

At first, I concentrated on planets. Jupiter was disappointing, even though its moons were exciting. Still, Jupiter appeared only as a white disk, as did Mars. And I never saw Saturn's rings. In fact, all the planets were identical. They were either unremarkable disks or brilliant specks of light: Were they mountains? Storms? Eyelashes? I worked myself into a state of befuddled frustration.

Two discoveries made all the difference. I finally installed my software, giving me the expert I wanted. Moreover, practicing with my telescope really paid off. Before, the planets were white disks because I had been magnifying them too much. Starting with Saturn, I focused back to the speck of light, and then adjusted ever so carefully. Lo and behold — I saw the rings of Saturn. The planet itself wasn't much bigger than a sesame seed, but I was thrilled, nonetheless. Next, I panned over to Jupiter. What exuberance in discovery! Although tiny, two prominent lines around Jupiter came into focus. Patience and persistence had seized the night sky for me at last.

While I possess more information and better tools than Galileo, I, too, experienced the surprises awaiting those who stumble in the dark. — William D. Heard, Dunlap, Tennessee

Here's what I've learned as a regular guy showing others the night skies: It's gotta move; be really big; or be really bright. Saturn always thrills, and your audience will stay for at least 30 minutes. — John Landreth, Chapel Hill, North Carolina

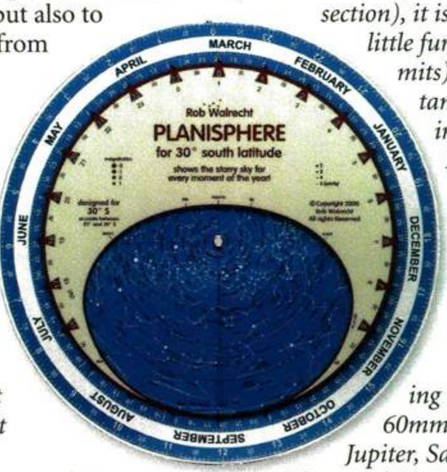
I have a suggestion to help explain the Earth/moon size comparison. Even though your daughter was satisfied when you described the moon as about a quarter the size of Earth (in diameter or visual cross-section), it is well worth pursuing the topic a little further (as long as her interest permits). A physical example, using tangible objects, could help her internalize a sense of scale. If Earth were the size of, say, a 4" softball, then the moon is approximately the size of a ping-pong ball (1.1"). — John Hopkins, Cambridge, Massachusetts

My sidekicks also enjoy observing the stars and planets through our 60mm refractor. Favorite objects are Jupiter, Saturn, and craters on the moon (always a hit). Sometimes I think they have more fun looking through the finderscope than through the telescope. (I must admit that the Pleiades look pretty cool through the finderscope.)

We put together a small "astronomy kit" that includes cutouts of the planets, a booklet with observing suggestions, and cards with a constellation on one side and a legend — from one of several different cultures — about that constellation on the reverse side. — Dave Miller, Woodridge, Illinois

Thanks to everyone who sent me notes. I look forward to your feedback at jerry@astronomy.com. Meanwhile, please check out *Astronomy* magazine's website, www.astronomy.com, for the forum section that encourages input from all levels of observers.

Now go enjoy the warmer nights and attend some star parties. And hey . . . don't be a quitter!



A planisphere is an easy-to-use, low-tech astronomy tool that lets you dial up your night sky simply by turning to the current date and time. Make sure it corresponds to your latitude. For customized planispheres, see www.walrecht.nl.

Target
earth & moon

cut along dotted line

NASA/JPL

Beginner's helpful tips

Visualizing Earth's place in space. By Carol Ryback

Ancient astronomers spent their lives figuring out stuff like which celestial body spun around which, and exactly where Earth fit into it all. Later, entire religions dictated how to view the architecture of the solar system. Thankfully, science moved on. But what of the wonder?

Well, it's still there, even though chances are good that more people will remember Earth as the third planet from the sun because of a now-defunct TV sitcom than from anything they learned in science class. Yet — if for nothing else — our present millennium must stand out as that in which humans forevermore possessed the ability to view Earth from space. This doesn't mean we're more intelligent than thousands of previous generations; indeed, we owe them a great debt. We simply enjoy better tools, not only for observing and understanding the universe, but also for explaining some mundane aspects of everyday astronomy:

Moon Face Never Varies

As you saw on the previous page, the moon is locked in a synchronous dance with Earth. But one of the hardest concepts to visualize is why we see only one side of our satellite.

Blame it on rotational periods — Earth and the moon spin at just the right speed, angle, and distance as they hang in space so that the moon always puts on the same face for us. The diagram on the following page helps explain the Earth-moon relationship and interaction.

Visualizing Planetary Conjunctions

May offers up great viewing for five naked-eye planets (Mercury, Venus, Mars, Jupiter, and Saturn) during the first half of the month. Make sure to catch it while you can, because once this amazing alignment disappears, it's gone until 2020. We see all these planets now because their orbits just happen to tilt at complementary angles to one another as well as to our line of vision as Earth passes through this area of space.

A Lighter Shade of Eclipse

Most Western Hemisphere viewers will witness a penumbral lunar eclipse on May 26. Watch for subtle but noticeable shading crossing the moon's southern portions. For a clear idea of how Earth, the moon, and the sun line up for this event, please refer to the bottom diagram on page 75.

Glossary

Aurora: A rapidly changing nighttime display of lights — more common over the polar regions — caused when charged solar particles collide with Earth's ionosphere; called aurora borealis in the Northern Hemisphere and aurora australis in the Southern Hemisphere.

Declination (dec.): One of the coordinates (analogous to latitude) on the celestial sphere that measures the angular distance from the celestial equator to an object; north is always positive and south is always negative.

Penumbral eclipse: When an object passes through the lighter, outer portion of a shadow cast by another celestial body.

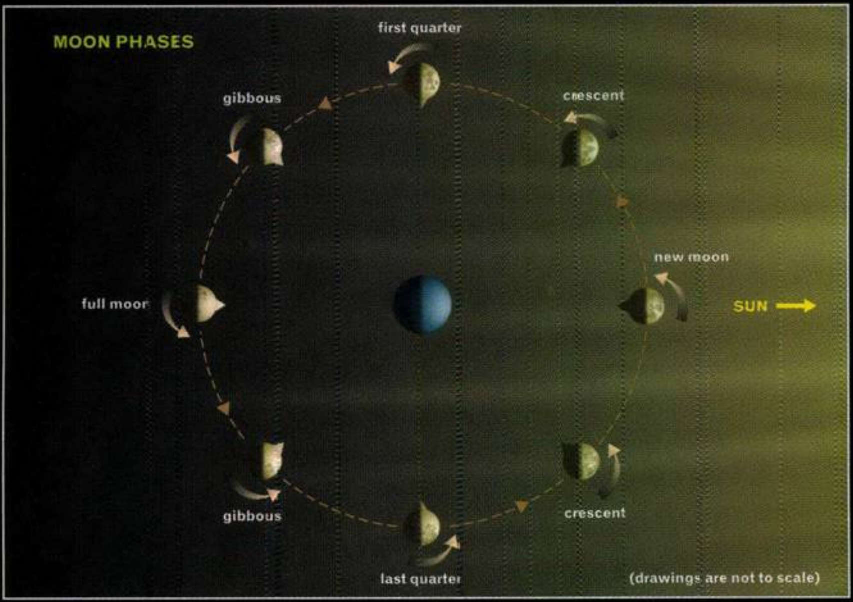
Right Ascension (R.A.): The second of two coordinates used to pinpoint a location on the celestial sphere; analogous to longitude, it is measured in hours, minutes, and seconds eastward from the zero point, which is the intersection of the celestial equator and the ecliptic at the vernal equinox.

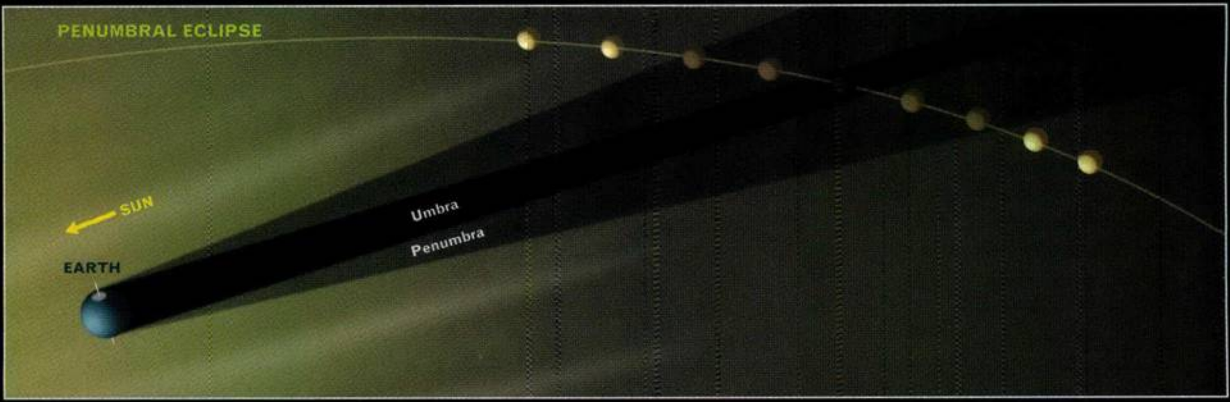
Synchronous rotation (also "captured rotation"): When a satellite's rotational period equals its orbital period, causing the same side of the satellite to always face the planet. This phenomenon explains why we always see the same face of the moon.

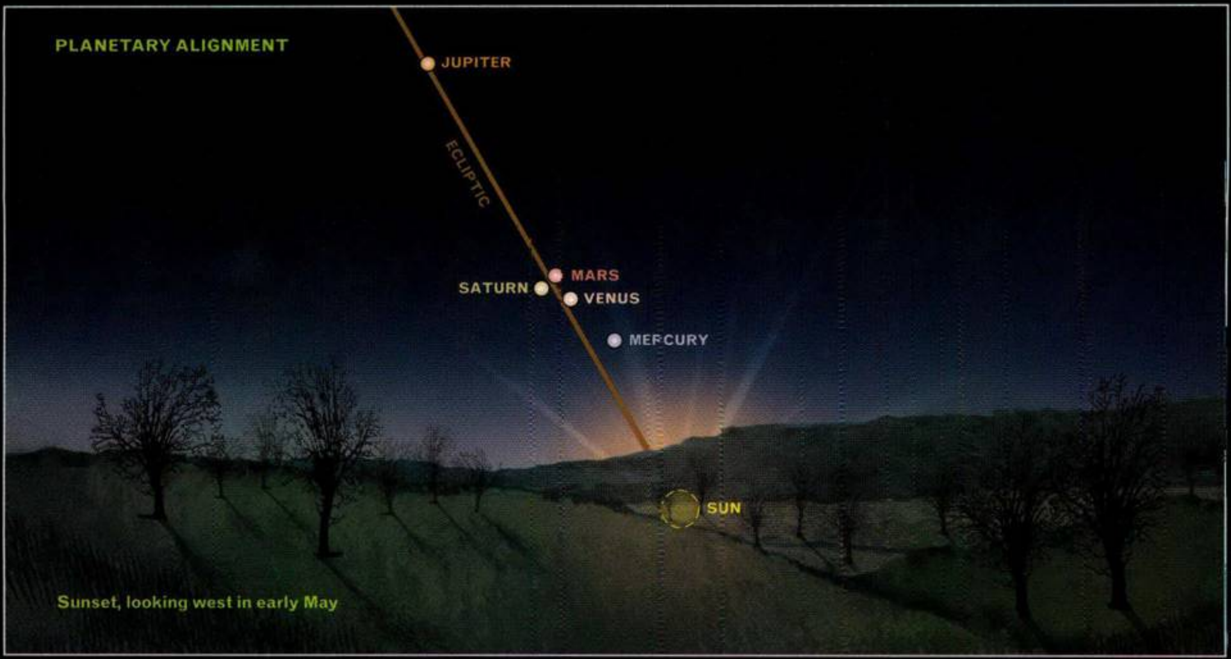
Terminator: The dividing line between the illuminated and dark part of a moon's or planet's disk.

Umbral eclipse: When an object passes through the darkest portion of a shadow cast by a celestial body.

Space views


MOON PHASES
first quarter
gibbous
crescent
new moon
full moon
SUN
gibbous
crescent
last quarter
(drawings are not to scale)


PENUMBRAL ECLIPSE
SUN
Umbra
Penumbra
EARTH


PLANETARY ALIGNMENT
JUPITER
ECLIPTIC
MARS
SATURN
VENUS
MERCURY
SUN
Sunset, looking west in early May

All 3 illustrations/ *Astronomy*: Kellie Jaeger

Catch an Extrasolar Planet

by David Hudgins

Last year the exotic worlds of Ray Bradbury and Isaac Asimov sprang to life for me as they once had in my boyhood dreams. Could an amateur astronomer really detect a planet orbiting a distant star? That challenge in the March 2001 issue of *Astronomy* ("Discovering Worlds in Transit" by Laurance R. Doyle, Hans-Jörg Deeg, and Jon M. Jenkins) fired my imagination.

We can't actually see extrasolar planets. They are too dim compared to the blazing star nearby. But in the past few years technology has caught up with knowledge, allowing the measurement of periodic wobbles in the motion of some stars that indicate the presence of orbiting planets. So far about 80 planets around other stars have been discovered by this indirect method. About 10 percent of sunlike stars seem to have Jupiter-sized planets in close orbits.

In 1999, two independent teams of researchers detected a planet in an extremely tight orbit around HD 209458, a star similar to the sun in the constellation Pegasus. The planet's orbital period is only 3.5 days, and it is closer to its star than Mercury is to ours. Because of these factors, a very high probability existed that the planet might pass in front of the star along our line of sight from Earth. If so, the star would dim slightly for a few hours as the planet crossed the parent star's much larger disk.

Astronomers David and Timothy Brown Charbonneau of the National Center for Atmospheric Research in Boulder, Colorado, detected this dimming in November 1999. Astronomers call this a transit, and it was the first time any extrasolar planet had been detected more or less directly. By knowing the size of HD 209458 (about 10 percent larger than our sun), it was also possible for the first time to measure the physical size of an extrasolar planet.

But could an amateur astronomer detect this distant planet? Absolutely. At least that is what I discovered while experimenting with a 10-inch SCT telescope and CCD camera in my suburban backyard. Spotting the planet was an

My Favorite Objects/Phil Harrington, Smithtown, New York

I seemed to be attracted to the universe as far back as first or second grade, but the night sky really came to life in sixth-grade science class. The solar eclipse in March 1970 and the bright tail of Comet Bennett got me hooked. While these interests continue, I'm mostly a passionate deep-sky observer. Even though I've been searching for, recording, and sketching deep-sky objects for more than 30 years, I've just begun to scratch the surface of what's out there.

The Orion Nebula

My most memorable view of M42 came through the homemade 32-inch reflector owned by John Vogt of Huntington, New York. We often observe together at Custer Institute on eastern Long Island. On one particularly clear, cold January night we experienced M42 as we had never seen it before. The four stars of the Trapezium glistened with a luster that I can't recall seeing before or since. Tinges of red, normally reserved for photographs, could be seen throughout the cloud complex, which showed an astonishing amount of detail and structure.

M6 and M7

My best view of these clusters came during the 2000 Astronomer's Conjunction annual meeting in Massachusetts. With 16x70 binoculars, I sat back and absorbed the scene for nearly half an hour as the clusters appeared to glide silently across the sky, just above the tops of distant pine trees. The 3-D effect was tremendous.

The Dumbbell Nebula

M27 has always been a summertime favorite of mine. I've always seen it as an apple core or an hourglass. My 8-inch scope fitted with a nebula filter and a little patience brings out the object's faint "wings" that extend from the tapered center of the hourglass.

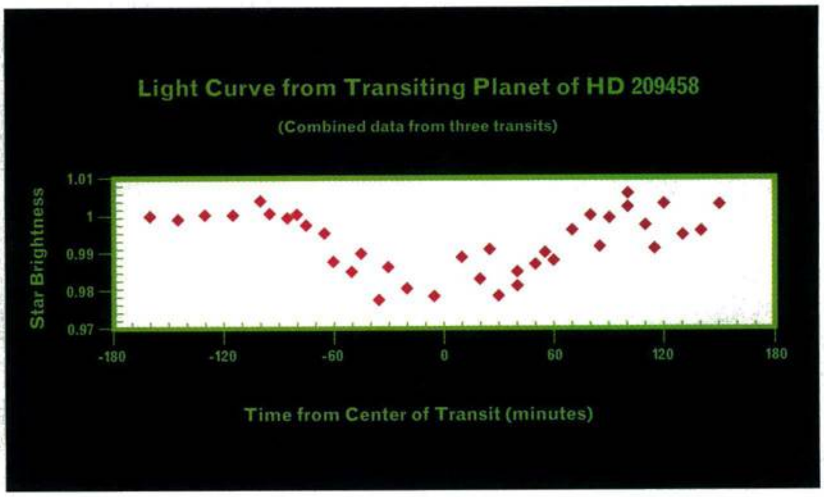
Phil Harrington

The Whirlpool Galaxy

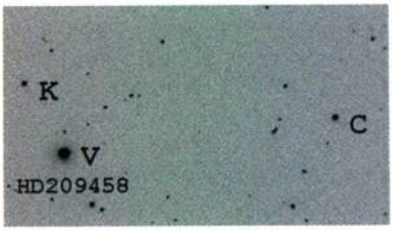
No other northern galaxy shows as much detail. In my 8-inch scope it takes a special night to see the galaxy's spiral structure. I can spot it regularly in my 18-inch scope from Long Island suburbia.

David Hudgins (3)

The author stands with his 10-inch SCT near Kansas City, used for detecting the planet orbiting HD 209458. A smaller scope could also do the job.



Above: The author's light curve for August and September 2001. Right: A typical image shows the target star V, comparison star C, and check star K.



exciting student research project for my Internet astronomy classes in the AIM program with the University of Western Sydney. And it was personally rewarding as well.

More technique than tools . . .

The bad news is that the planet (slightly larger than Jupiter) reduces the light from its parent star by only a tiny 1.5 percent. That's too small to detect visually, but it can be detected by careful measurement of CCD images. The good news is that the magnitude-7.6 star is easy to find, and the planet orbits so quickly that an opportunity to observe the three-hour transit occurs about once a week. To conduct your search you will need a CCD camera and telescope of 4-inch aperture or larger on a good mount.

Check David Charboneau's website at http://www.astro.caltech.edu/~dc/frames.html for predicted transit times. I found these accurate to within a few minutes.

The basic idea is to take CCD images of HD 209458 and its surrounding starfield. I did this every ten minutes. If possible, start taking images an hour before the transit is to occur and continue imaging until an hour after the end of the transit to be certain of capturing the necessary data in your light curve.

With careful photometric techniques (more on this in a moment) you should be able to detect a change of as little as 0.01 magnitude with a single image. Your observation will be more useful to scientists if you accurately record the exposure time using one of the WWV radio atomic clocks (tune to 5, 10, or 15 megahertz).

My initial results were disappointing, with errors of 0.04 magnitude — far too great to detect the transit. But with experimentation and helpful advice from experts, I found several essential tricks that made precise measurements possible:

- Read up on CCD photometry (http://infomagic.net/~ccdir/howto.html and http://infomagic.net/~ccdir/hipre. html)
- Select comparison stars that are in the same field, and as similar in magnitude to the target star as you possibly can.
- Expose the CCD to record maximum pixel values of about 50 percent of saturation of your camera.
- Flat field carefully, and during the three-hour transit, keep adjusting the telescope to keep the target star on the same spot on the chip.
- Slightly de-focus the star images — this spreads the light over more pixels and assures better measurements.

Even a small telescope can detect this planet. The real key is developing your technique so that you can consistently measure the difference in magnitude between the target star and comparison star within 0.01 magnitude.

Take lots of samples

A single image is barely adequate to record the slight dimming caused by the planet. Better results and a smoother light curve can be obtained by taking a larger sample of images. Quickly take a burst of ten or more CCD images at regular intervals. The results can then be averaged for each time increment to produce a better, higher resolution light curve.

I measured changes in the brightness of HD 209458 using a method called differential photometry. In this technique, widely used by variable star observers, the target star is measured against a comparison star in the same field.

In addition, the comparison star itself is measured against a third star. This assures that the magnitude changes seen in the target star are real — not due to atmospheric factors or other causes.

Measurements for differential photometry are easily performed using software products like AIP4WIN (Willmann- Bell, Inc.). Other software products include

MIRA and IRAF (for systems such as Unix and Linux).

Typically, I took about 300 images during a transit. This is easier than it sounds using software supplied with many CCD cameras such as the SBIG products. After measuring each image, I collected the data in an Excel spreadsheet. Graphs were made right from the spreadsheet. If all goes well, the predicted light dip will appear and you will join the ranks of a small group of amateur observers who have spotted an extrasolar planet.

Light curves reveal the planet

Detecting the light dip is actually just part of the fun. A light curve showing the entire three-hour transit reveals an amazing amount of information about the planet and its orbit. The accuracy of this information depends on how precisely you measure the light dip and determine the start and end of the transits. With my backyard equipment, knowing the size of the star HD 209458, and using some high-school math, I "discovered" the following facts about this extrasolar planet:

- Planet diameter: 96,000 km.
- Mass: 1.39 times that of Jupiter.
- Orbital period: 3.5234 days.
- Transit time: 2 hours 48 minutes (±21 minutes).
- Orbital inclination: 2.7 degrees to our line-of-sight.

I was delighted to find that these results — made with only modest amateur equipment — compare amazingly well with results from professional researchers.

This truly is a golden age for dedicated amateur astronomers who want to make a contribution to science. Many more activities are now within the reach of backyard scientists. But not exclusively: It's also a great time for more casual observers wishing to satisfy daydreams of exploring distant worlds first sparked by the sci-fi writers of our youth.

David Hudgins is an active observer and astroimager in the Kansas City area. He wishes to acknowledge advice from Richard Berry, Arne Henden, and Miroslav Filipovic.

Experiments with Wide-Spectrum CCD Imaging

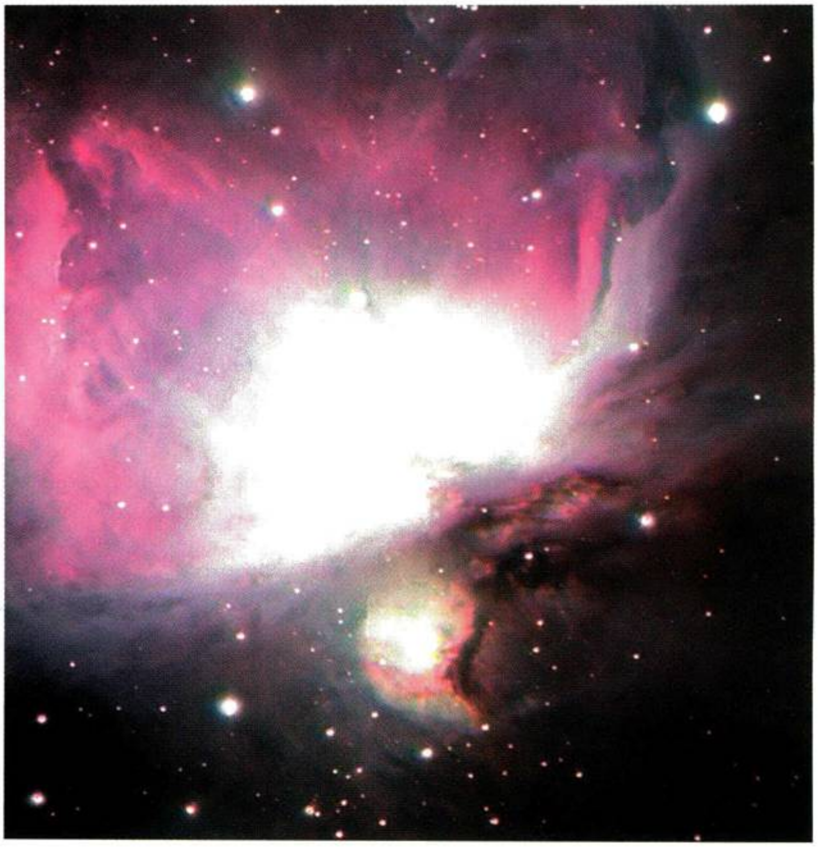
by Paolo Candy

The existence of ultraviolet radiation was demonstrated by Johann Wilhelm Ritter in 1801, who created a solar spectrum with a prism and observed the darkening in a sheet of paper soaked with silver chloride in the area above the violet. Infrared radiation was discovered by William Herschel in 1800, during his studies of visible light. Measuring the temperature with a thermometer near the solar spectrum, Herschel noticed an increase in the region beyond the red, because of an invisible source of radiation.

Fortunately for us, molecular ozone and oxygen in Earth's atmosphere block the most energetic ultraviolet radiation from reaching Earth's surface. A small amount penetrates, however, giving us a danger of too much sun exposure. The ultraviolet that reaches Earth's surface is confined to a narrow window between 300 and 400 nanometers. The atmospheric window into the infrared is wider, allowing this radiation through to the surface in the range of 700 to 1000 nanometers, unblocked by water vapor and carbon dioxide.

When I saw the amazing infrared imaging of the 2MASS survey (Two-Micron All-Sky Survey, see *Astronomy*, November 2001), I determined to try to make some wide-spectrum CCD images that would show infrared features in familiar sky objects. The technique produces some surprising results. In visible light, the clouds of nebulous gas appear detailed. An infrared view, however, allows us to peer deeply into the center of a nebula and to see the myriad young stars embedded in it. Light pollution on Earth is not much of a problem because its emission is outside the realm of the infrared. The resulting technique of wide-spectrum infra-

The Orion Nebula, M42, imaged by the author with a 7-inch apochromatic refractor at f/9 from his observatory in the Cimini Mountains, near Viterbo, Italy. The CCD composite is an LRGB, with 240-second exposures made in red, green, blue, and luminence bands, and assembled in digital desktop software. The result is quite stunning. Paolo Candy



red imaging gives us a new view of some old familiar objects.

The technique uses three filters to produce three CCD exposures that can then be combined into a single finished frame using any one of several software packages now on the market. There's an analog to the 2MASS survey at work. 2MASS works simultaneously at 1250 nm (J band), 1650 nm (H band), and 2170 nm (K band). By correlating J to blue, H to green, and K to red, color photos are created in a range of hues from 2MASS data.

The result is that giant and supergiant red stars appear extremely bright and some nebulae are evident, as with the Orion Nebula and the Omega Nebula. We can detect astronomical objects in the interstellar dust of the galactic plane; details in dusty galaxies and clouds producing stars in the Milky Way will be more evident.

Challenging Comets/ May 2002

In any month, several comets normally glow brightly enough to become visible to those with large telescopes. Here are coordinates and magnitudes:

C/2002 C1 (Ikeya-Zhang)

Apr. 21	22h08.5m, 60°13', 5.2
May 1	19h08.7m, 58°54', 5.8
May 11	17h09.7m, 45°56', 6.7
May 21	16h13.4m, 31°37', 7.6
May 31	15h45.2m, 20°17', 8.6

C/2001 OG108 (LONEOS)

April 21	9h18.1m, 56°57', 10.4
May 1	9h30.5m, 31°32', 11.1
May 11	9h38.6m, 14°52', 12.0
May 21	9h46.2m, 4°24', 12.8
May 31	9h54.1m, –2°39', 13.6

C/2001 N2 (LINEAR)

Apr. 21	20h25.3m, 18°15', 14.6
May 1	20h16.2m, 19°21', 14.3
May 11	20h02.8m, 20°26', 14.1
May 21	19h44.1m, 21°20', 13.9
May 31	19h19.3m, 21°51', 13.6

C/2001 SV74 (LINEAR)

Apr. 21	0h40.6m, 69°10', 14.0
May 1	1h01.9m, 72°08', 14.0
May 11	1h29.3m, 75°13', 14.0
May 21	2h07.7m, 78°21', 14.0
May 31	3h08.6m, 81°17', 14.0

22P/Kopff

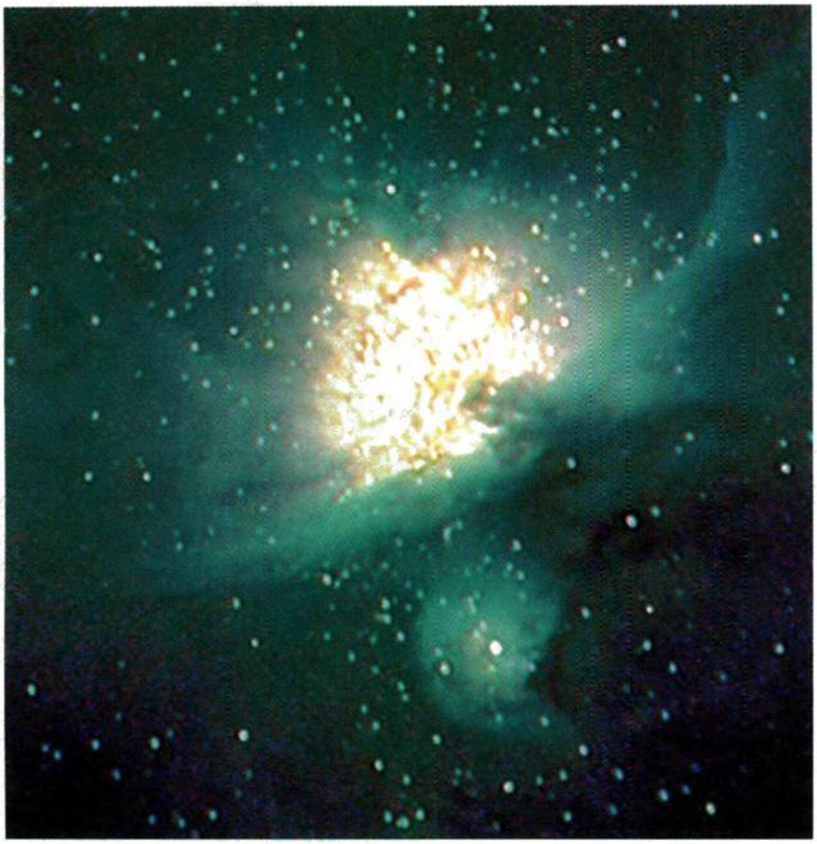
Apr. 21	11h41.1m, 8°58', 15.2
May 1	11h36.0m, 9°21', 15.0
May 11	11h33.4m, 9°25', 14.8
May 21	11h33.5m, 9°09', 14.6
May 31	11h36.2m, 8°35', 14.4

C/2001 HT50 (LINEAR-NEAT)

Apr. 21	10h02.4m, –5°31', 14.8
May 1	9h54.7m, –4°22', 14.8
May 11	9h48.6m, –3°19', 14.8
May 21	9h44.1m, –2°26', 14.8
May 31	9h41.1m, –1°41', 14.8

29P/Schwassmann-Wachmann 1

May 1	21h05.9m, –18°12', 15.5
May 11	21h08.6m, –17°55', 15.4
May 21	21h10.2m, –17°43', 15.4
May 31	21h10.7m, –17°35', 15.3



Compare the visual CCD composite at left with this image, made with the same equipment, but with the author's infrared composite CCD imaging technique. Three infrared wavelengths were given 240-second exposures and assembled via software. Note the abundance of young stars that have formed from the coalescing gas in the nebula. Paolo Candy

For my technique I have divided the infrared spectrum into three parts, 700 to 800 nm; 800 to 900 nm; and 900 to 1000 nm. I consider these the three channels. The filters I have chosen are the Schott RG 715 (by now named IR1, 700 nm and above); Schott RG 850 (IR2, 800 nm and up); and Schott RG 1000 (IR3, 900 nm and above).

If the IR1 needs an exposure of 1x, then the IR2 needs 1.2x as much exposure and the IR3 5.5x that exposure to produce a well-balanced set of results. I set the band 700 to 800 nm as blue; 800-900 nm as green; and 900-1000 nm as red. Combining the images can be done with AstroArt or MaxIm.

I hope that by sharing these images, I can inspire others to try wide-spectrum imaging. ■

Paolo Candy is director of the Cimini Astronomical Observatory in the Cimini Mountains of Italy.

ask Astro

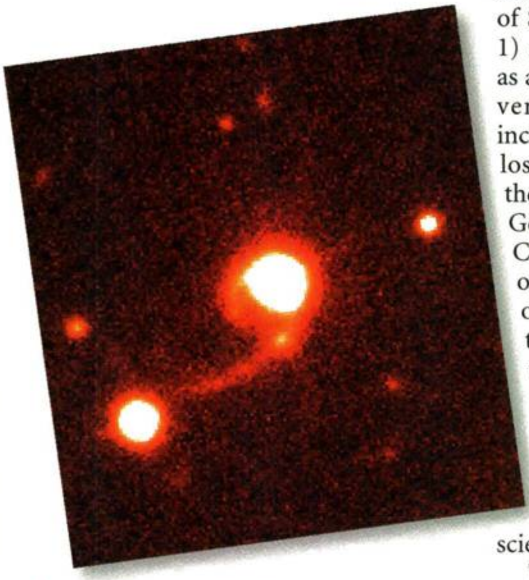
Quasars, Vatican Astronomy, Heavy Elements from Supernovae

Why are there no quasars nearer to us than a billion light-years or so? And, if the Andromeda Galaxy were a quasar, what would be its apparent magnitude in the night sky and would Earth be in any danger? — *Michael Alvarez, Glen Easton, West Virginia*

For decades, the enigmatic nature of quasars foiled scientists seeking their secrets. But in the last 10 to 15 years, astronomers have developed a compelling picture: A quasar is the highly luminous center of a distant galaxy powered by the accretion of material onto a supermassive black hole at the galaxy's core.

They appear so far away because the universe works like a time machine. Light travels at a finite speed — albeit a fast one of 186,000 miles per second — so we see objects as they once were. Our view of the moon, about 240,000 miles away, shows it as it was 1.3 seconds ago. The sun's light started its 93-million-mile journey toward Earth 8 minutes ago. The Andromeda Galaxy, some 2.2 million light-years away, appears as it was 2.2 million years ago.

Yet quasars belong to an entirely different realm. The closest ones, like 3C 273 in Virgo, lie roughly 2 billion light-years away. And the most distant lie some 13 billion light-years from Earth. The universe was only a billion years old when the light from these quasars started on its way. A census of the more than 10,000 quasars known shows they reach a maximum density at a distance of 12 billion light-years, and most lie between 11 billion and 13 billion light-years away. Quasars obviously represent a phenomenon of the early universe. The few nearby ones are simply the last of a dying breed.



The distant quasar HE 1013–2136 (center) draws material from its surroundings. ESO

Where did they go? The black holes that power quasars still exist — astronomers find them in the center of nearly every galaxy. But they no longer draw in much material. The early universe was much smaller than today's, and collisions and mergers between galaxies happened much more frequently. With much less material to feed these black holes, active galaxies today have much lower luminosities.

Now back to Andromeda. It's easy to calculate how bright the Andromeda Galaxy would be if it were a quasar. Typical quasars release as much energy as 100 trillion suns, making them 100 times brighter than the brightest normal galaxies. Drop a source like that into a galaxy 2.2 million light-years away and you get an object shining at magnitude –2.6. That's about as bright as Jupiter appears at opposition, though fainter than Venus. That's pretty bright, but still much too faint to pose any danger to Earth or to life. — *Richard Talcott, senior editor*

Why has the Vatican invested so much energy in studying astronomy? Has equal effort been spent on other areas of scientific interest, such as biology, geology, psychology, or physics? — *Elliot Jasper, Missoula, Montana*

The Church's interest in science goes back to its beginnings. In Genesis we were told that the universe was created by God, who found it good; one of St. Paul's epistles (Romans, Chapter 1) notes that the created world serves as a pointer to God. The medieval universities, founded by the Church, included astronomy and "natural philosophy" in their curriculum. Albert the Great has been called the father of Geology; Roger Bacon, the father of Chemistry; Gregor Mendel, the father of Genetics; Angelo Secchi, the father of Astrophysics; and Georges Lemaître, the inventor of the Big Bang theory. All were priests or monks. For most of history, scientists have tended to be clergymen — until the 19th century, they were the ones most likely to have the education and free time necessary for scientific research.

The Vatican's direct connection with astronomy dates from Pope Gregory XIII's reform of the calendar in 1582. The Council of Trent had instructed the Pope to consult astronomers to correct the old Roman calendar (which by then was more than a week out of

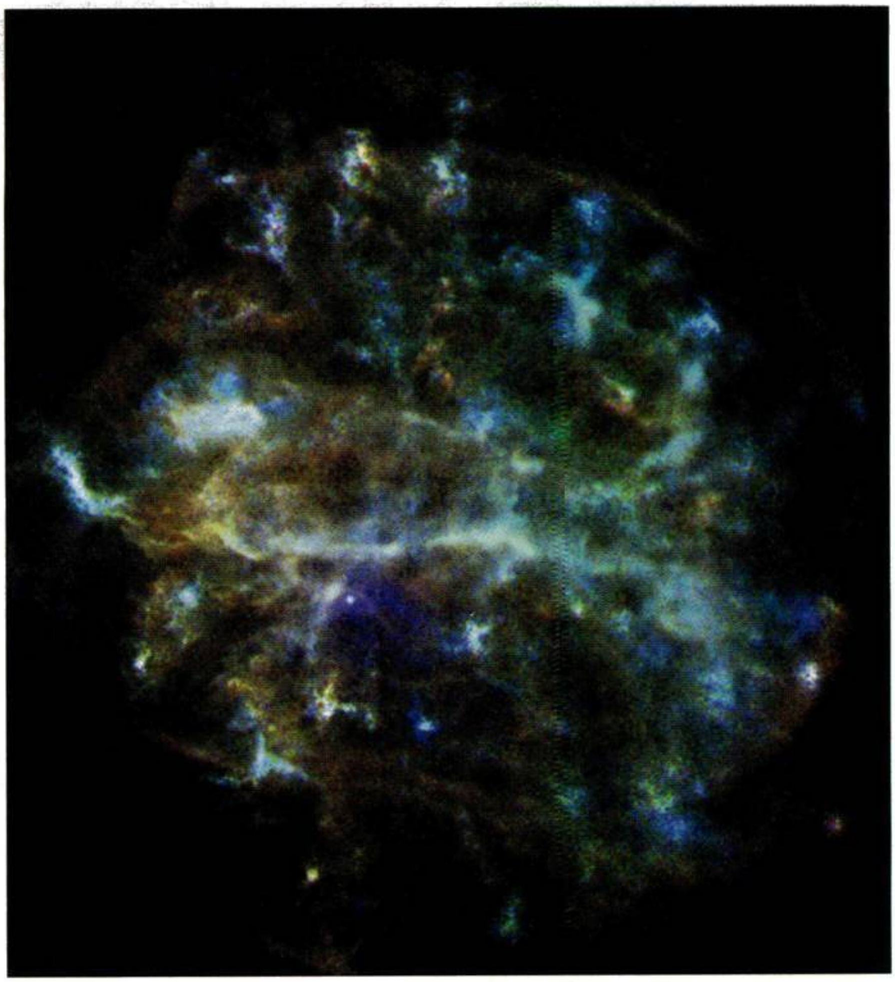
The Vatican Advanced Technology Telescope sits atop Mount Graham. Vatican Observatory

synch with the seasons) and to find a better way of fixing the date of Easter and other religious holidays. The work was entrusted to a committee headed by Fr. Christopher Clavius of the Roman College. After that time, Jesuits at the Roman College continued to advise the Vatican on astronomical matters, and in the 18th century the name "Specola Vaticana" (Vatican Observatory) was applied to the astronomical and meteorological research there. With the unification of Italy in 1870, however, the Roman College was taken over by the Italian government.

About that time, the high point of the pre-quantum mechanics "mechanistic" view of the world, some writers tried to claim that the Church was opposed to scientific knowledge. (For a history of those assertions, see Steven Jay Gould's book *Rock of Ages.*) To counter that claim, in 1891 Pope Leo XIII established the Vatican Observatory to show that "the Church and her Pastors are not opposed to true and solid science, whether human or divine, but that they embrace it, encourage it, and promote it with the fullest possible dedication" (quoting the papal letter, Motu Proprio). The Pope acted on the urging of his friend, the Barnabite priest Francesco Denza, who was expert in physics, meteorology, and astronomy.

At that time, astronomers in France were proposing an international program called the Carte du Ciel (Map of the Heavens), the first photographic survey of the entire sky. Fr. Denza proposed that the Vatican take part in this work as a dramatic way of making the Church's support of science obvious to the world. From that point, the Specola has concentrated on astronomy in its various forms.

Despite the popular misconception, the Vatican's resources are quite limited — its annual budget is considerably smaller than that of many American archdioceses, for instance. Thus astronomy is the only science currently being supported directly by the Vatican. However, there are Pontifical Academies of both Science and Social Sciences; these are groups of prominent scientists from a wide variety of backgrounds, nationalities, and faiths, who serve to advise the Vatican on matters of their expertise. — *Brother Guy J. Consolmagno S.J., Vatican Observatory Research Group, Steward Observatory*



This supernova remnant appears rife with heavy elements. NASA/CXC/Rutgers/J. Hughes, et al.

Considering the enormous power of supernovae to scatter material in every direction, how do heavy elements become highly concentrated in isolated areas of Earth's crust?— ***Thomas Strobel, White Bear Lake, Minnesota***

Although supernovae scatter heavy elements in all directions, physical and chemical processes within a geologically active planet like Earth can concentrate those elements. For example, many of the heaviest (highest atomic number) elements have radii that are too large to be accommodated easily inside the crystal structures of minerals. They thus become concentrated in molten regions of Earth.

As molten rock (magma) cools, releasing crystals, these "incompatible" elements do not fit into crystal lattices and so become further concentrated in the remaining liquid. Thus the highest concentrations of the heaviest elements found in the crust — ore bodies — are often associated with the final dregs of cooling magma. More generally, earth scientists think the crust originated from melt that rose out of the underlying mantle, so it's especially enriched in rare heavy elements.

In the case of heavy elements that are relatively abundant in the cosmos, such as iron, there's enough high-mass material for it to collect and sink. Scientists believe Earth's metallic core arose from this sinking of iron, and the elements that alloy easily with iron, and think it occurred early during the formation of our planet. — *Raymond Jeanloz, Earth and Planetary Science and Astronomy Departments, University of California, Berkeley*

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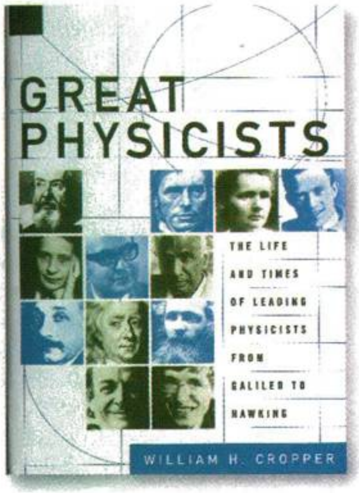
Great Physicists: The Life and Times of Leading Physicists from Galileo to Hawking

William H. Cropper, 500 pages, Oxford University Press, New York, 2001; ISBN 0–19–513748–5; hardcover, $35.

▶ If you're curious about the world around you and wonder how things work, you'll find a lot of thought-provoking information in William H. Cropper's *Great Physicists*. But reading it will take some time and dedication on your part, because he has packed 30 profiles of famous as well as lesser-known physicists into 500 pages of text with few illustrations.


GREAT PHYSICISTS
THE LIFE AND TIMES OF LEADING PHYSICISTS FROM GALILEO TO HAWKING
WILLIAM H. CROPPER

Cropper cautions the weak-hearted in his preface: "Mathematical equations express the language of physics. You can't get the message without learning something about the language. That should be possible if you have a rudimentary knowledge of algebra . . . and pay attention," he warns. So be prepared to dust off your old math books if you want to fully absorb everything that's contained within.

Despite this, Cropper wisely includes enough personal information about each of his subjects to make them come alive and summarizes complicated concepts in interesting and understandable terms. Sure, there's some technical jargon, but don't let it intimidate you.

The author has done a good job of packaging his product. Instead of arranging 400+ years of scientific discovery into a chronological sequence — from Galileo to Stephen Hawking — the profiles are divided into four categories: mechanics, thermodynamics, electromagnetism, and microphysics (the world of the atom).

If you want to see how all the pieces fit together in order, Cropper provides a year-by-year listing at the end, from Galileo's birth in Italy in 1564 to the detection of a new neutrino in 2000.

Threaded into several profiles is the intricate story of how America acquired the foreign intellectual expertise to build atomic bombs at Los Alamos and end the war in August 1945. Einstein and others who knew about Germany's plans had persuaded Franklin Roosevelt to launch the Manhattan Project.

However, Neils Bohr, a Danish physicist who helped the effort, feared any one nation having such awesome power and urged FDR and Winston Churchill to share the secret with Joseph Stalin in Russia. In 1944, Bohr almost went to jail for that unpopular idea.

Adolph Hitler's Nazis and the rise of fascism in Italy greatly affected the development of physics during World War II. Cropper vividly describes the conditions in prewar Europe that forced brilliant physicists such as Albert Einstein and Enrico Fermi to escape to the West, bringing with them the mental tools to protect freedom and democracy.

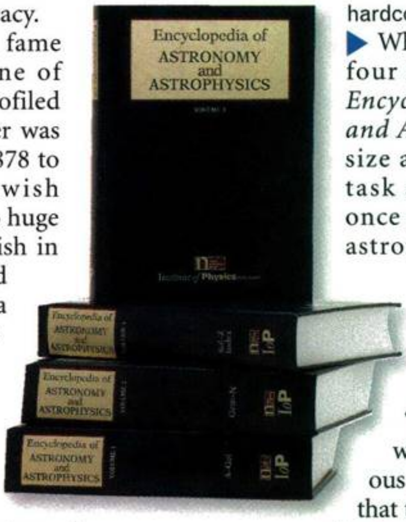
Of lesser-known fame is Lise Meitner, one of only two women profiled in this book. Meitner was born in Austria in 1878 to a middle-class Jewish family. She faced two huge obstacles: being Jewish in Hitler's realm and being a woman in a traditionally man's world of science. But she overcame those barricades to visualize nuclear fission — a term she borrowed from biologists who used it to describe cell division. Even though German armies were overrunning Europe and German scientists were working on an atomic bomb, Meitner refused an invitation to join Fermi and others in the United States to build a nuclear weapon at Los Alamos. She could not justify the use of science to kill people, even in wartime for the best of causes.

Nearly all the physicists profiled in this book faced personal barriers, but none was more challenged than Marie Curie, the Polish governess who aspired to a life in science. She and her French husband, Pierre, discovered the radioactive elements radium and polonium in 1898 after boiling up a brew of chemicals in a miserable old outdoor shed. As a reward, she and Pierre suffered from radiation sickness.

Here's an incidental nugget: If you think Galileo performed his famous acceleration of gravity experiment from atop the Leaning Tower of Pisa in Italy, think again. You'll have to read *Great Physicists* to discover the truth. — *Nick Nichols is the retired news media relations manager at the Idaho National Engineering and Environmental Laboratory in Idaho Falls.*

Encyclopedia of Astronomy and Astrophysics

Paul Murdin, Editor-in-Chief; Foreward by Sir Martin Rees, four-volume set, copublished by Nature Publishing Group Reference and Institute of Physics Publishing, Groves Dictionaries, New York, 2001; ISBN 1–56159–268–4; hardcover, $650.



▶ When I first received the four large volumes of the *Encyclopedia of Astronomy and Astrophysics*, its sheer size and weight made my task seem daunting. But once my husband (also an astronomer) and I started looking through the pages, we were hooked.

Over the next few days we kept saying, "Did you know this?" As we read through the various entries, it became clear that these volumes were destined to become an important resource — not only for us, but also for all those interested in astronomy.

The set consists of four massive books averaging 1,000 pages each. It provides an extensive and wide-ranging reference source which would be most useful to professional astronomers, teachers, and graduate and undergraduate students, as well as advanced amateur astronomers. It contains about 700 lengthy review articles written by experts in their respective astronomy subfields. Additionally, about 1,800 short entries give concise definitions of terms, objects, biographies, and anecdotes about space missions and major observatories. (The latter overviews of major observatories and space missions — not commonly found in many other reference works — were welcome additions to these volumes.)

One way that this set differs from more general astronomical dictionaries is that it contains in-depth review articles covering areas of active research. These long, review-style articles are up-to-date and authoritative. The exhaustive information contained therein would be most useful for advanced undergraduates or for graduate students seeking knowledge in a new area of astronomy. Each section was written by an expert in that field, leading to differences in style between sections; some are also better written than others. Generally, each article begins with an overview targeted at general readers of science. Others become very specialized and use explanations with advanced equations that are geared more toward intermediate or advanced astronomers.

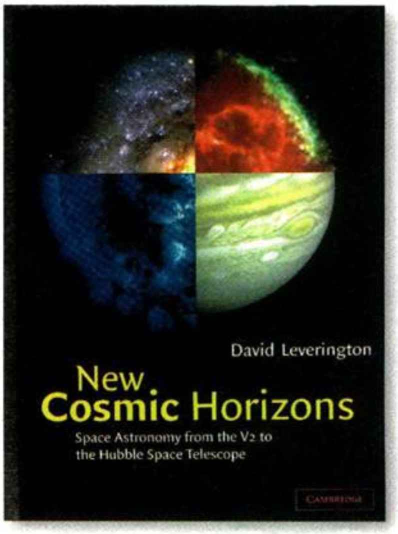
Interspersed with the extensive review articles in the *Encyclopedia* are a vast number of short, dictionary-style entries useful for anyone interested in astronomy. These provide succinct biographies of astronomers, definitions of terms, summaries of celestial objects, and descriptions of observatories. We especially liked the "M" section, which includes a summation of the physical properties of the Messier objects. Most amateur astronomers would find these very interesting. Each Messier entry begins with a brief visual description of the object, followed by a history of its exploration, and ends with a description of its physical properties, such as distance and size. Much to the joy of my husband (who is an extragalactic astronomer), several of the extragalactic Messier objects — such as the Andromeda Galaxy (M31), M82, and M87 — have several pages of in-depth information. However, as a galactic astronomer, I was a bit chagrinned that no galactic nebulae — not even the famous Orion Nebula (M42) — rated an equally in-depth review.

Overall, the *Encyclopedia of Astronomy and Astrophysics* is spectacular in both breadth and depth. The majority of the images are in black and white, and while useful, are not particularly eye-pleasing. There are color inset pages in each volume as well. However, you must flip back and forth between the color insets and the associated article. The index given in Volume Four is both useful and necessary. For example, there is no entry for "brown dwarf" in the *Encyclopedia,* but when you refer to the index you find that brown dwarfs are combined with extrasolar planetary companions.

The information in the *Encyclopedia of Astronomy and Astrophysics* is current and topical. The editors plan to electronically update about one-fifth of the set each year. For an annual $200 fee, you can access the website information.

We visited this site frequently to assess its contents and discovered links between *Encyclopedia* entries as well as to related articles. The quality of the website images vary widely.

Other links include the "Pictures of the Week," "Breaking News," and space and solar weather reports. Most of this material is unremarkable and available elsewhere at no cost. On most of our visits we found the website too slow to be truly enjoyable. While the ability to browse and search the *Encyclopedia* is useful, the greatest asset of the electronic version is that it can be continually updated.



So who should buy the *Encyclopedia of Astronomy and Astrophysics?* Given that these volumes are destined to become a major astronomical reference work with broad appeal, nearly every public or school library should have one. Furthermore, it would be a must for any science, physics, or astronomy library. If you're an avid amateur or professional astronomer you would surely enjoy owning these volumes. — *Elizabeth Lada and Richard Elston are professors of astronomy at the University of Florida. Elizabeth studies the formation of stars and their planetary systems in the Milky Way Galaxy, while Richard builds astronomical instrumentation and studies the evolution of galaxies and their clusters in the distant universe.*

New Cosmic Horizons: Space Astronomy from the V2 to the Hubble Space Telescope

David Leverington, 520 pages, Cambridge University Press, New York, 2001; ISBN 0-521-65137-9; hardcover, $85; ISBN 0-521-65833-0; softcover, $30.

▶ Humans are explorers by nature. And while Columbus, Magellan, and others explored planet Earth, scientists like Johannes Kepler and Isaac Newton contemplated leaving Earth to explore the realm beyond.

In fact, Kepler's dreams of a moon landing, as recorded in his science fiction fantasy, the *Somnium,* were not realized until three centuries later.

The human presence in space began some 50 years ago. In *New Cosmic Horizons,* author, engineer, and scientist David Leverington examines the history of space astronomy from the sounding-rocket era to the Hubble Space Telescope. Leverington covers all of the major missions — American, Soviet, European, and Asian — in the first half-century of space exploration. He also examines the early science

(continued on page 87)

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The Webweaver Picks

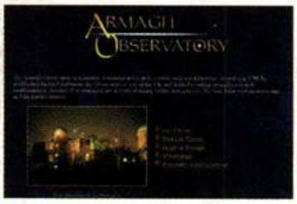
by Richard Bartlett

Northern Observatories Virtual Tour

Last month I covered the observatories of the Southern Hemisphere, so this month we're going to take a tour of Europe.

First stop is the Armagh Observatory in Northern Ireland, whose website is http://star.arm.ac.uk/.

The institute's 25 research astronomers investigate everything from astrophysics to Earth's climate. It's closed to the public, but the AstroPark — an outdoor scale-model of the cosmos — and planetarium are nearby.



Next we'll sail the Irish Sea to London and visit the Royal Greenwich Observatory. The website, http://www.rog.nmm.ac.uk/, provides observatory information as well as the latest astronomical news and up-to-date night sky events. The 28-inch telescope is open to the public between September and July, with evening sessions planned between November and March.

Next we'll drive southwest to the coastal resort of Sidmouth and the Norman Lockyer Observatory. Funded by the local government, the observatory is dedicated to astronomical and radio research.

It's open to visitors during winter evenings and afternoons in July and August, as well as on holiday weekends. Please check out the website at http://www.ex.ac.uk/nlo/ for more information.

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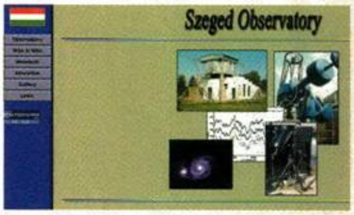
After crossing the English Channel to France, let's travel to Paris. Here we'll find the historic Royal Observatory whose directors included Cassini, Lalande, and Le Verrier. It's open to the public on the first Saturday of each month. Expect at least a three-month wait when you book your party. The website — http://www.obspm.fr/obsparis.en.shtml — is fairly basic, but lists tourist information and helpful directions.

Moving on, we'll cross southeast into Switzerland. In Bern we find the Zimmerwald Observatory (http://www.cx.unibe.ch/aiub/). Its astronomy equipment includes a 600mm Cassegrain and a one-meter ZIMLAT (ZIMmerwald Laser and Astrometric Telescope) telescope for Satellite Laser Ranging (SLR) work and CCD imaging. It's open to the public every Thursday evening.

Traveling through neighboring Austria, we reach the University's Institute for Astronomy in Vienna, built in 1755. Visit the friendly dual-language website, http://www.astro.univie.ac.at/ for more details.

Our next stop is the university of Szeged, south of Budapest, Hungary. Four telescopes are in everyday use, with research focusing upon variable stars and minor-planet observations. The university offers astronomy courses, and the observatory is open to the public every Friday evening. The website — http://www.jate.u-szeged.hu/obs/index_en.html is simple to use.



North of Vienna, in the Czech Republic, is Hradec Kralove, east of Prague. Its observatory and planetarium are open to the public every Wednesday, Friday, and Saturday evening. Like the university at Szeged, the main scientific work consists of variable star and minor-planet observations. The website, http://www.astrohk.cz/indexen.html, is fairly text-heavy, but the English is very good and someone clearly has a quirky sense of humor. Click on the link for a map.

We're now in the final stage of our tour, so let's cross into Germany. In Berlin we find the Wilhelm-Foerster Observatory and Planetarium. Its homepage is http://ods.schule.de/schulen/wfs/ehompage.html.

Although it's not flashy, it's certainly one of the most welcoming. To quote the front page, "The stars at the observatory are open to be watched by people of all nations," and there is a willingness to arrange lectures in English, French, and Spanish. Unfortunately, I found no information on the observatory itself.

We've traveled quite a way now, and deserve a break. Catch a flight south to Sicily and we'll enjoy the sun at Palermo on the northern coast of the island. While we're here we can also check out the 200-year-old observatory on the edge of the city center. This provides a link to Paris, as the great Giuseppe Piazzi spent time at both observatories and discovered the asteroid Ceres at Palermo on New Year's Day, 1801. The museum is open daily to visitors and the observatory provides telescope time with its 14-inch telescope every month. Get complete details online at http://www.astropa.unipa.it/versione_inglese/homeinglese.html.

It's nearly time to head for home, but as we bask in the Sicilian sun, let's contemplate our next destination. Both AstroPlace at http://www.astroplace.com/amateurs/observatories.asp and the Milkyweb observatory guide at http://www.observatory-guide.org/ list hundreds of observatories located all over the world. Some belong to amateurs, some to professional institutions. But all prove one thing: Anyone can appreciate a good telescope and clear skies.

Visit Richard's StarLore website at http://www.starlore.net.

missions, the first forays into the space just above Earth, manned and unmanned lunar missions, planetary missions, Skylab, and all the major scientific satellites up to the Hubble Space Telescope. We are reminded that like the early mariners' explorations beyond Europe, the early history of space exploration was motivated more by politics than by the drive to do science.

Leverington is eminently qualified to write a book on space astronomy. He spent over a quarter of a century working in the aerospace industry during what was arguably the most exciting and rapid growth period, from 1969 to 1995. Rather than simply extolling the virtues of space exploration, Leverington examines the many failed attempts to reach targets and comments on both the economic cost (in current terms) as well as the scientific gain. This will be particularly enlightening to the under-35 crowd, many of whom are likely unaware of the many early failures experienced by both the American and Russian space programs. We also see the evolution of space exploration from political shows of technical and scientific power to science-driven missions with planetary scientists and astronomers leading the way.

The early space missions are discussed in essentially chronological order; however, missions are usually discussed as American and then Russian. Later material tends to be ordered in terms of subject, such as missions to the outer planets versus solar missions.

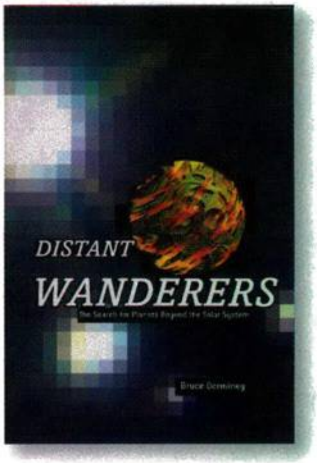
Leverington's style is refreshingly matter-of-fact compared to the typical popular science book, but this may take getting used to, and at first seems a bit dry. By the time you reach the second chapter you are fired-up and ready to keep reading.

There are plenty of black-and-white photographs of satellites and astronomical objects as well as a number of descriptive summary tables. In addition, there is a handy glossary for astronomical and geological terms. *New Cosmic Horizons* should have broad appeal — it's an interesting, engaging read for the general reader and a good reference book for any astronomer who teaches introductory astronomy courses. — *Jennifer Birriel, Morehead State University*

Distant Wanderers: The Search for Planets Beyond the Solar System

Bruce Dorminey, 226 pages, Copernicus Books, New York, 2002; ISBN 0-387-95074-5, hardcover, $29.95.

▶ Acclaimed science journalist Bruce Dorminey is well known for his engaging and thorough reports from science's cutting edge. And in his first book, *Distant Wanderers: The Search for Planets Beyond the Solar System*, Dorminey hits the mark again with the most up-to-date and complete account of the ongoing hunt for elusive extrasolar planets.



With an eclectic narrative style equally fitting for a travel journal and a scientific monograph, Dorminey injects his personal experiences with planet hunters, their prey, their weapons, and their hopes and fears throughout each chapter of *Distant Wanderers*. At the beginning of chapter four, for instance, the reader is instantly transported to the scene where Dorminey first meets the dynamic duo formed by extrasolar planet hunters Geoff Marcy and Paul Butler at a café on the Italian isle of Capri in 1996. Later, Dorminey takes readers to the Atacama desert on a lonely observing run at the desolate La Silla Observatory in southern Chile.

Dorminey's journalistic skills allow him to succinctly expand on the technological, cultural, and philosophical ramifications of the search for planets like our own, while simultaneously delivering uncompromising explanation of the science behind the search. It's an enjoyable book for both armchair enthusiasts and astronomy professionals.

But *Distant Wanderers* is perhaps most impressive for its efficiency. Dorminey packs a wealth of timely information into an easily manageable span of just over 200 pages. Readers will discover definitions and explanations for some of the more cumbersome astronomical topics like interferometry and stellar evolution scattered throughout the book. Additionally, each chapter is generously illustrated with photos, graphs, and tables.

Perhaps most importantly, Dorminey successfully injects personality into the pages — thanks to extensive interviews and revealing quotes from scientists. There aren't many places where you can find Geoff Marcy speaking so candidly about the likely proliferation of extrasolar planets. On page 59 Marcy says, "Some might be crummy little Earth-like planets, some of them might be Neptunes and Saturns, but I bet that at least half of all stars have full-fledged planetary systems. I'd bet my house on it."

Dorminey also gives the reader a glimpse of what lies on the horizon. He explains how astronomers are refining interferometry and gravitational lensing research techniques with the hope of (someday) directly detecting not only Earth-like planets, but also the signatures of living organisms light-years away. Moreover, he devotes the last two chapters to life, intelligence, and the search for both beyond the solar system.

In the end, *Distant Wanderers* leaves you feeling in the know about the search for distant planets and all that it entails, now and in the future. — *William Schomaker, associate editor*

The Grip of Gravity: The Quest to Understand the Laws of Motion and Gravitation

Prabhakar Gondhalekar, 358 pages, Cambridge University Press, New York, 2001; ISBN 0-521-80316-0; hardcover, $28.00.

▶ Gravity is the weakest of the fundamental forces of nature: Compared to interatomic forces, gravity is weaker by 40 powers of 10. Yet gravity plays a major role on Earth because its 10^{80} atoms are all pulling in the same direction at the same time. This concept of gravity churned in Isaac Newton's mind as — fleeing Cambridge from the Plague in 1665 — he passed his days speculating about why the moon orbited Earth, eventually finding his legendary revelation when the apple fell.

Newton went on to invent calculus, although the Germans assigned priority to Gottfried Wilhelm Leibnitz, and showed that gravity flattened the rotating Earth, much to the consternation of the French astronomers. Newton won this debate. This and more we learn from *The Grip of Gravity*, by Prabhakar Gondhalekar, a delightful, historical tour of our exploration and understanding of gravity over the centuries.

The last word in gravity returned to Germany as Albert Einstein, based in Berlin from 1914 to 1933, supplanted Newton's theory of gravity with the Theory of General Relativity that he announced in 1916. According to Einstein's geometric theory, gravity operates by curving space, and particles of matter follow the trajectories of curved space. Sir Arthur Eddington eagerly jumped upon the new theory and mounted an expedition to observe the total solar eclipse of 1919.

Banner headlines greeted the astonishing results that Eddington unleashed on the unsuspecting. Gravity curves space and predicts double the light deflection of a star viewed near the sun as does the original corpuscular theory of light in flat space. Einstein was right; space is curved.

Time is also distorted by gravity. Clocks slow down. The frequency of light emitted by a source in a gravitational field is lowered, as viewed by a distant observer. The effect that one infers on the surface of Earth is small, only amounting to about one part in a billion. Harvard University constructed a physics laboratory without nails (in the interest of avoiding weak magnetic effects) that detected a differential gravitational redshift and provided frequency measurements with an accuracy of one part in 10^{15}.

Time dilation turns out to have practical effects. It's used in synchronizing cruise missile orbits with the global positioning satellite system (GPS). Without orbital correction from General Relativity, a cruise missile on a transcontinental flight would miss its target by a kilometer or more.

The inescapable grip of gravity makes the world go round. Gondalekhar's book provides a fascinating and readable account of gravity's power in guiding our understanding of the cosmos. — *Joseph Silk, University of Oxford, United Kingdom*

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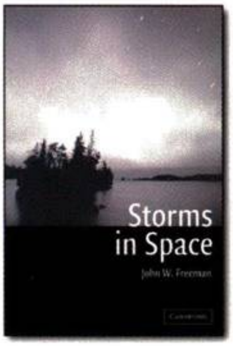

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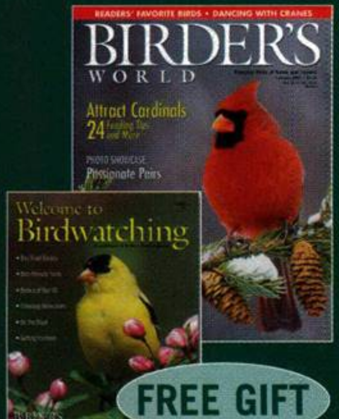
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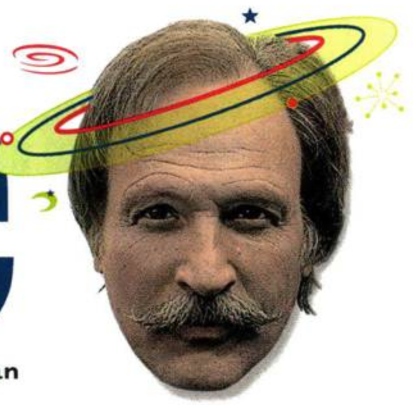

by Bob Berman

Catch of the Day

No Hype: Extraordinary sights unfold in May, with the first great conjunctions of the 21st century. All five naked-eye planets strikingly gather, and nothing like it will again be seen until autumn 2040. This is the sort of thing that once inspired fun-loving Mayans and other primitive people to bang drums and push reluctant virgins off pyramids. (Why did high priests call it a sacrifice when they always insisted someone *else* be thrown off?)

Spread over many nights, May's sky follies are cloud resistant and require only a clear western view. The best observing time is around 9 P.M. when nautical twilight ends. The month opens with bright Mercury just 7° high, dazzling Venus to its upper left, side-by-side Mars and Saturn a bit higher still, and brilliant Jupiter above them all. Like a school of fish, every bright planet swims in one small cove of sky.

And the fishing only improves. On May 6, Venus, Mars, and Saturn huddle tightly together. On the 9th and 10th, Venus and Mars nearly merge. A skinny, low crescent moon passes to Mercury's left on the 13th; the next night it beautifully meets Venus. Starting the 31st, Jupiter and Venus rendezvous for several days. While these fine displays carry the naked eye on free excursions, May's planetary free-for-all will also provoke stranger kinds of attention.

Dive back to long ago, when every ancient civilization noticed that Mercury and Mars are orange-yellow, Saturn creeps sluggishly, Mars grossly changes brightness, Jupiter is always brilliant, and Mercury darts around quickly. Each culture correctly perceived remoteness and majesty in these exotic lights that seemed to circle Earth obsessively, but they also wanted to make sense of it all. And here is where they went wrong.

None guessed that they were looking at big balls of the same basic sort of material found in the soil beneath their feet. To most cultures these odd lights were gods, or at least supernatural heaven-stuff.

The nightly changes of these bright "stars" are currently so obvious and striking, it's easy to pretend you're a primitive person watching their curious movements. You'd probably reach conclusions popular in ancient Greece. If these really are gods that influence us personally, you might well assume fast-moving Mercury must have something to do with life's rapid changes. You have a backache one day but it's gone the next — mercurial stuff like that. Super-luminous Venus easily gets the love vote; if you don't associate love with the most brilliant "god" then love has passed you by.

Mars is reddish and changes brightness frequently. A no-brainer: blood, burns, flames, war. What else could be causing that color — geraniums? Jupiter's stately motion and great steady brilliance suggest a god that is beyond care and downright jovial. So the boss planet is Jove, by Jove. Finally, poor Saturn's plodding slow motion must mean it's sad or heavy; in a word, saturnine. It all made sense way back then.

While early skywatchers can't be blamed for this simplistic silliness, today's astrologers, displaying a spectacular collective inability to learn anything since the 16th century, still believe planets possess these traits. That's why two billion people imagine May's conjunctions will affect their lives in some personal way.

The roots of such egocentric notions are obvious, the big mistake being the assumption that planets act the way people do. Astrology still hasn't gotten the catch — the universe is not obligated to conform to human psychology.

Exploring planets without science is like trying to seize water with open fingers. Nonetheless, a vast ocean may lurk beyond the continents of reason and superstition alike. We reach its mysterious shores whenever we ask what happened before the Big Bang or try to visualize other dimensions or wonder how electrons can simultaneously exist and not exist at a given place. We've come a long way since Babylon, but Houston, we still have a problem.

The trouble is with the question, not the answer. Our logic system evolved to deal with everyday things like cheeseburgers, birthday gifts, and even planetary motion. But we've never seen quarks and never will, so why should our vocabulary be adequate to explain their appearance or behavior?

Logic permits us to form seemingly reasonable questions, such as "Is the universe infinite or does it have an end?" Then we torment ourselves because we lack a complete answer. But consistently unsatisfactory answers should sound a warning buzzer: The question itself may be defective, probably because it's phrased in the language of past experience.

If math doesn't come to the rescue, Newtonian, Einsteinian- or Bohrian-type leaps may do the job. Or it may require accessing or acquiring other levels of cognition. The deepest and most satisfactory fundamental understandings of the cosmos may prove to be wholly non-verbal. After all, words and concepts rely on comparisons with what's already known, an enormous limitation. Just as a person born blind cannot understand "blue," we may not yet be able to visualize quantum superposition or the oddities of empty space simply because they don't compare with anything here on the hamburger level. Yet, like love and other imponderables, it can still be real even if it is difficult to define in words.

Moreover, much exists beyond what science chooses to quantify or probe. Returning to the planets, for example, I think that each exudes a unique "feeling" that produces distinct sensations in the observer. Almost everyone looking at Saturn through a good telescope is awestruck.

While the Space Telescope's Saturn images are clearer than views through any backyard instrument, Saturn's backyard presence packs a punch that Hubble images lack. What is this powerful impact that no photo can convey? Maybe there's no science or language for it, but the feeling at the eyepiece is marvelous all the same. And I suspect it's real rather than subjective because everyone reacts the same way.

Just as a flame conveys a different impression than a stone, each planet delivers its own distinctive flavor the way each member of your family has his or her own "presence." If you've aimed telescopes at planets for awhile, you know what I mean.

I think these sensations, as much as anything else, pull us out to gaze at planets for the thousandth time. They're like old friends. And they're beautiful, pure and simple. Complementing the science and observing fun, we get the artistry and visceral impact at no extra cost. No wonder May's fireworks in Taurus will resonate with everyone who loves the sky.

Sensations? Planet ambiance? It may sound strange but it's old stuff to longtime observers, who cast their nets into the universe to fish for impressions as much as knowledge.

Anyway, it doesn't matter: Whatever you're angling for in May's starry sea, it's there for the taking. ▣

Bob Berman's "Strange Universe" column is a regular feature in Astronomy. *Berman, an avid sky watcher, has authored two wonderful books on astronomy:* Secrets of the Night *and* Cosmic Adventure.

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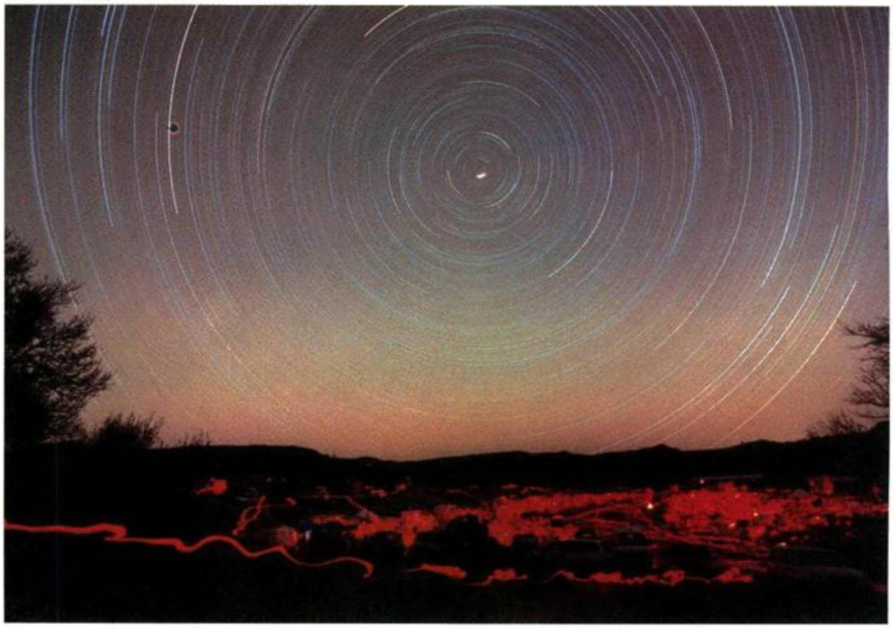
The stars at night are big and bright, deep in the heart of Texas." So sang Gene Autry and so hope attendees to the various star parties and Astronomy Day celebrations held across Texas this spring.

The most popular of astronomical gatherings in Texas is the Texas Star Party, held May 5 through 12 at the Prude Ranch near Fort Davis. Co-sponsors Texas Star Party, Inc. and the Southwest Region of the Astronomical League have an exciting week planned for visitors. Besides observing, activities include swap meets, contests, showcases, bus tours of McDonald Observatory, and the Great Texas Giveaways.

To register, contact Anne Atkins, TSP Registrar, 4812 Twin Valley Drive, Austin, Texas 78731. For more information, visit the TSP website at http://www.metronet.com/~tsp/index1.html or e-mail tspreg@metronet.com.



Mark Schroeder

Star trails shone and red flashlights glowed as night fell at the 2000 Texas Star Party.

APRIL 12–13

Central Texas Star Party

Eagle Eye Observatory, Canyon of the Eagles Lodge and State Park, near Burnet, Texas. Sponsored by the Austin Astronomical Society, this twice-yearly star party affords amateurs an opportunity to observe under some of the darkest skies in Texas. Entry to the park is $5 for adults, $4 for senior citizens, and free for children under 14. Lodging is available from the park. For more information, e-mail aas-info@kirchhof.com; website, http://www.austinastro.org.

APRIL 12–13

Lake Whitney State Park Astronomy Day Celebration

Lake Whitney State Park, Whitney, Texas. Celebrate Astronomy Day with telescope making, videos, games, guest speakers, and telescope observations. For more information, visit their website, http://whitney-astro.com.

APRIL 19–22

University of Arizona Alumni Association Astronomy Camp

Catalina Observatories, Tucson, Arizona. Sponsored by the University of Arizona Alumni Association, this is a combined camp for both beginner and advanced adult astronomers. For more information, contact Don McCarthy, (520) 621–4079; 933 N. Cherry Ave., Tucson, Arizona 85721–0065; e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astrocamp.

APRIL 20

Boston Museum of Science Astronomy Day

Museum of Science, Boston, Massachusetts. Dynamic exhibits, programs, exciting hands-on activities and demonstrations will be presented throughout the day. In the evening (weather permitting) a star party will take place on the roof of the museum's garage. For more information, contact Noreen Grice, (617) 589–0273; e-mail, ngrice@mos.

APRIL 20

Dallas Astronomy Day

Richland College, Dallas, Texas. The Texas Astronomical Society of Dallas will be hosting Astronomy Day 2002 at Richland College in Dallas, Texas. Events begin at 11 A.M. and include hourly planetarium shows, lectures, mirror-grinding and telescope-making presentations, multimedia exhibits, hands-on activities for kids, and telescope viewing until 11 P.M. For more information, contact Dan Doyle, P.O. Box 703247, Dallas, TX 75370–3247; (972) 394–5694; e-mail, starmandan@hotmail.com; website, http:// www.texasastro.org.

MAY 16

The Universe at Midnight: Observations Illuminating the Cosmos

Chabot Space and Science Center, Oakland, California. 7:30 P.M. Part of the Distinguished Lecturer Series. Ken Croswell's most recent book, *The Universe at Midnight*, published in September 2001, describes recent revelations in cosmology, including the surprising discovery that the universe's expansion is accelerating. During the talk, he will use the latest cosmological discoveries to offer a brand new forecast for the universe's fate. Tickets for this lecture are $5 and can be purchased online. For more information, contact (510) 336–7373; website, http://www.chabotspace.org/.

MAY 17–19

Sky Tour 2002

Near Bellevue, Ohio. Sky Tour is the annual star party hosted by the Huron Valley Astronomers Group and Tech2000. For more information, contact Tech2000, 69 Ridge St. Monroeville, OH 44847; e-mail, tddi@accnorwalk.com.

MAY 24–MAY 26

Astronomy Expo

Y.M.C.A. campgrounds, near Big Bear City, California. The 33rd annual Riverside Telescope Makers Conference is organized around the themes of "Deep Sky" and "Women In Astronomy." Activities include a swap meet, lectures, family activities, contests, and of course, observing. For more information, contact (909) 948–2205; e-mail, rstephens@foxandstephens.com; website, http://www.rtmc-inc.org/.

MAY 25

Shreveport-Bossier Astronomical Society Star Party

Ralph A. Worley Observatory, Shreveport, Louisiana. For additional information, contact (318) 797–1524; e-mail, clucas@softdisk.com.

JUNE 7–9

Jersey StarQuest 2002

Hope Conference and Renewal Center, Hope, New Jersey. Sponsored by the Amateur Astronomers Association of Princeton, Inc., StarQuest will feature dark skies, astrophotography workshops, dealers, swap tables, and a flea market. Registration deadline is May 22, 2002. For more information, contact Anthony Monticello, Registration Chairperson, 270 Fieldboro Drive, Lawrenceville, NJ 08648; e-mail, anthony_monitcello@hotmail.com.

JUNE 14–JUNE 15

32nd Apollo Rendezvous

Boonshoft Museum of Discovery, Dayton, Ohio. Sponsored by the Miami Valley Astronomical Society of Dayton, the Apollo Rendezvous will feature speakers, competitions, numerous vendors, door prizes, contests, planetarium shows, presentations, and a Saturday night stargaze. For more information, contact Manning Butterworth, (937) 485–9766; e-mail, rendezvous@mvas.org; website, http://www.mvas.org/rendezvous.html. ■

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our online calendar at http://www.astronomy.com.

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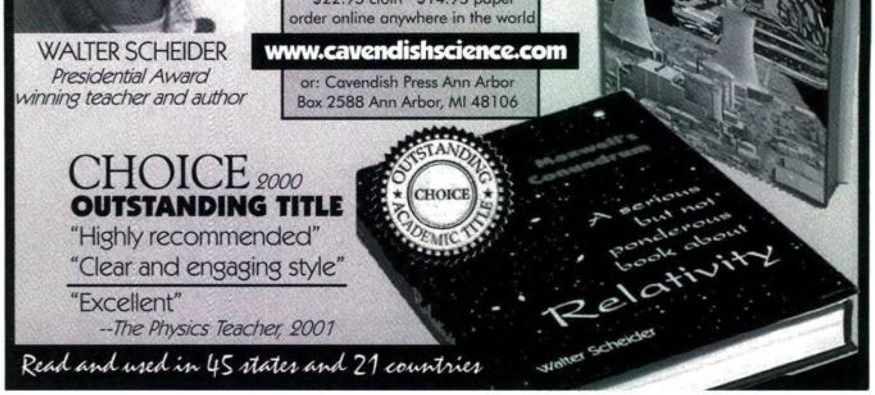

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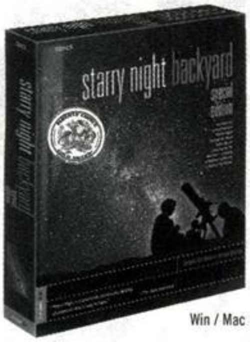

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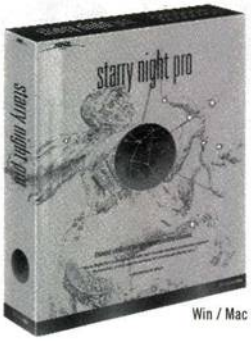

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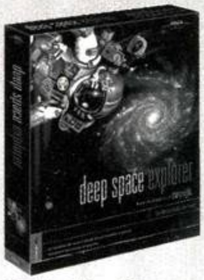

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ALCON 2002 27
ASM Products 97
Adorama 18,19
Africa Eclipse Tour 2002 99
Analytical Scientific 96
Astro Camp-Camp Eberhart 94
Astro Physics 91
Astronomics 20
Astronomy Magazine 99
Astronomy.com 29
Astronomy Magazine 105, 121
Astrotec 97
Atomic Time 91
Beigle/Bryant Engineering 97
Bethany Sciences 96
Birder's World Magazine 89
Cambridge University Press 88
Camera Bug 97
Cavendish Press 93
Celestron International 25
Day Star 23
Eclipse 2002 Tour to Australia 18
Eclipse Edge Expeditions 23
Focus Camera 32-33
Glatter, Howard 98
Hands on Optics 31
Hardin Optical Co. 23,93
Holiday Inn Puerto Vallarta 97
Into the Wind/The Kite Source 98
JMB, Inc 31
Knollwood Books 97
Kool Space Science Productions 98
Kowa Optimed Inc 94
Learning Technologies, Inc. 88
Lumicon 71
MIT Professional Institute 23
Mag One Instruments 98
Marketplace Pages 96,97,98
Mayhugh Travel 98
Meade Dealer Pages 12, 13
Meade Instruments Corp 2,3,7,8,9,10,11,106
Mobile Skies.com 98
Mountain Skies Astronomical Society 98
New Mexico Skies 96
Newport Glass Works 98
Nisur Systems 96
Observatory Inc, The 97
Oceanside Photo & Telescope 17
Orion Telescopes & Binoculars 50,105
Outer Edge Expeditions 98
Rainbow Symphony 97
Rivers Camera Shop 29
Royal Cruise Adventures 98
SAC Imaging Systems 96
SCS Astro 96
Scientifics 91
Scope City 29
Shutan Camera & Video 85
Sirius Observatories 98
Sirius Travel-Eclipse Tour 96
Sirius Travel-Southwest Tour 96
Star Hill Inn 96
Star Tek Industries 98
Starizona 93
Starry Night 94
Starsplitter Telescopes 96
Stellarvue 97,98
Surplus Shed 96
T &T Binocular Mounts & Beyond LLC 96
Tech 2000 98
Technical Innovations 31
Terlingua Ranch Lodge 96
Travel Quest 96
Travel Wizard 97
University Optics, Inc. 97
Woodland Hills Photo Images 31
www.bigbinoculars.com 98

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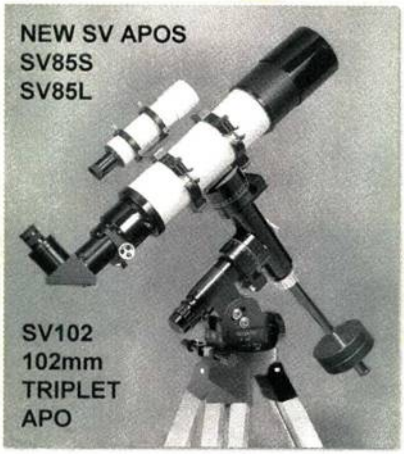

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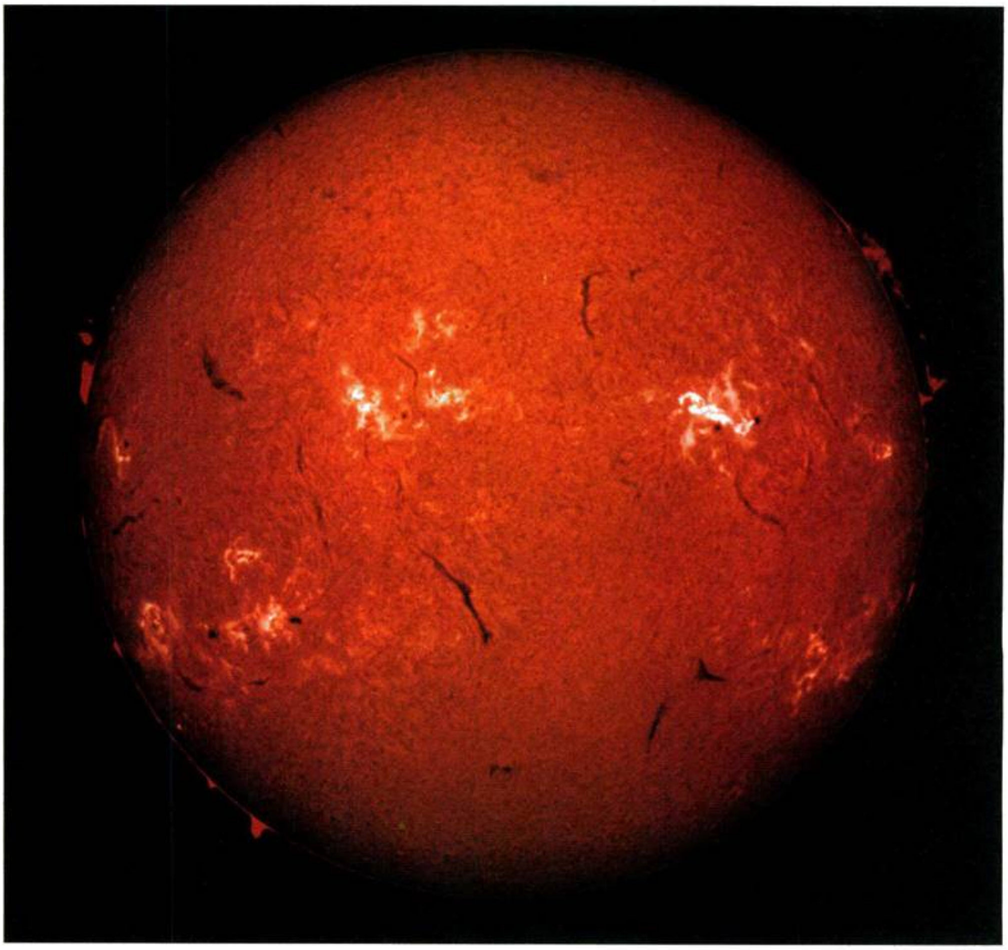
Persian Stars

▶ It's 6 P.M. on a cold winter evening. I set up my photographic gear and wait impatiently for twilight to show its wonderful colors. A gentle wind blows into my face from the west. Each minute passes by and I grow more and more impatient: The weather chills, promising a crystal-clear winter sky for star-trail photography. I can't touch my camera tripod.

Every ten minutes or so I go inside a simple building nearby, an Emam-Zadeh (the place of a grave for holy Muslims) to warm myself. Minutes later, an old, kind, rural woman brings out an oil-operating heater and some homemade bread for me. I look outside to the darkened environment from behind the fogged windows of my simple resting place; the time has come to begin another session of capturing the sky.

In the remote rural villages of Iran, in the "Alamoot" region of the country, I'll capture more stars tonight. I'm in the central Alborz mountains, some 125 miles northeast of Tehran.

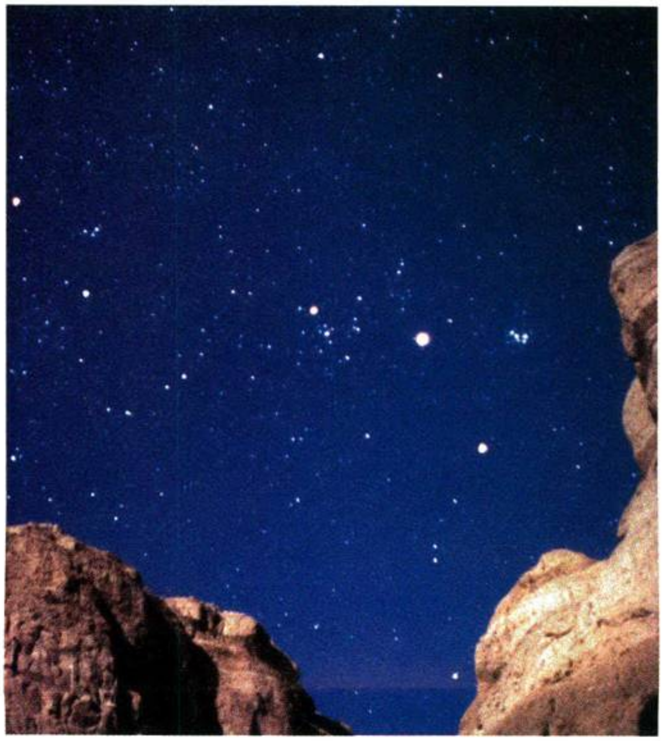
During my 10 years of photographing sky objects, I've traveled to different corners of Iran in quest of combining the country's rich history with the sky. During these trips, which I have taken without any personal transport vehicle, I have met different people with diverse moods and cultures but with one thing the same: their love of the sky. I have captured churches, mosques, and fire temples of different



Brilliant Solar Flare

JEFF PETTIT

(4-inch refractor, Daystar 0.5 A H-α filter, composite of 1/60- and 1/4-second exposures taken October 19, 2001)



Jupiter and Saturn in Taurus

JERRY SCHAD

(24mm lens at f/1.7, Kodak P1600 film pushed to ISO 3200, 35-second exposure taken December 16/17, 2000) cultures and periods. The starry sky remains fixed in all of these, the one with the same constellations visible no matter where we live on the planet.

When I capture a lonely tree along with circumpolar stars, especially in wintertime, I can imagine its branches begging for the stars, like the hands of a human stretched skyward in prayer.

When I shoot an important event like an eclipse from an important historical landmark such as Pasargade — the tomb of Cyrus the Great, founder of the Achemenian Empire in Persia some 2,500 years ago — I feel that I'm going back in time. Long-exposure photography in exotic historical places provides a special look to the buildings or ruins. Combining these monuments of ancient times with the stars, in fact, is combining them with infinity. Star trails above ancient places make you feel a connection to the past.

Heavenly bodies such as the moon, planets, and constellations give a special kind of holy, serene, out-of-this-world look to Earth's cultural heritages. ■

Oshin D. Zakarian is an amateur astronomer living in Tehran, Iran.

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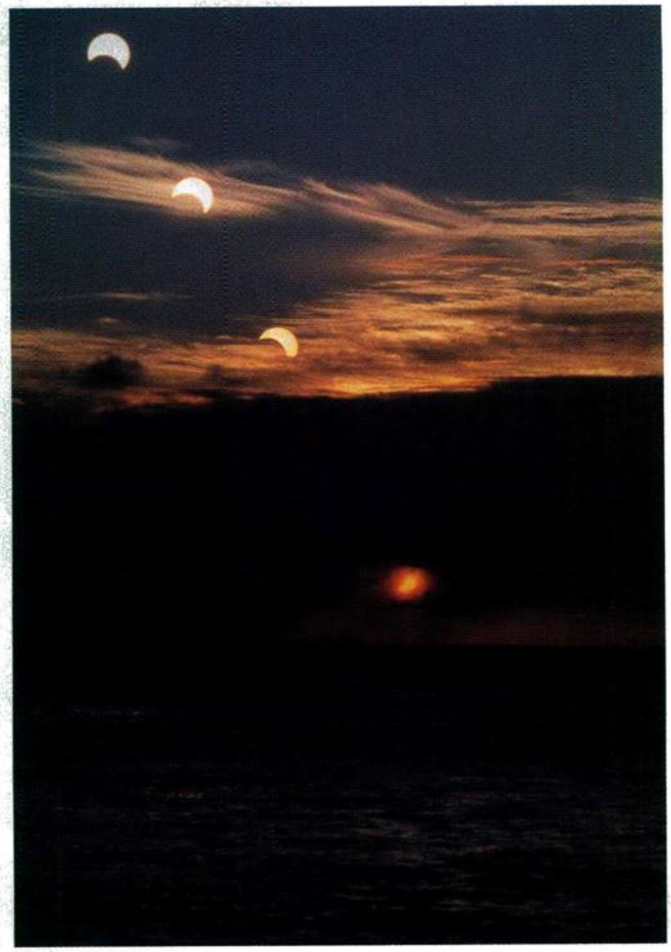


Annular Eclipse over Key West

RICH SCARPITTA

(200mm lens at f/22 and 125mm lens at f/8, Elite 100 film, composite image taken December 14, 2001, from Key West, Florida)

IC 405 and IC 410 in Auriga

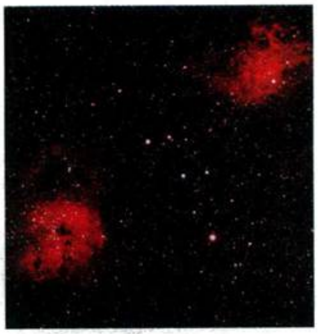
DAVID MESSIER

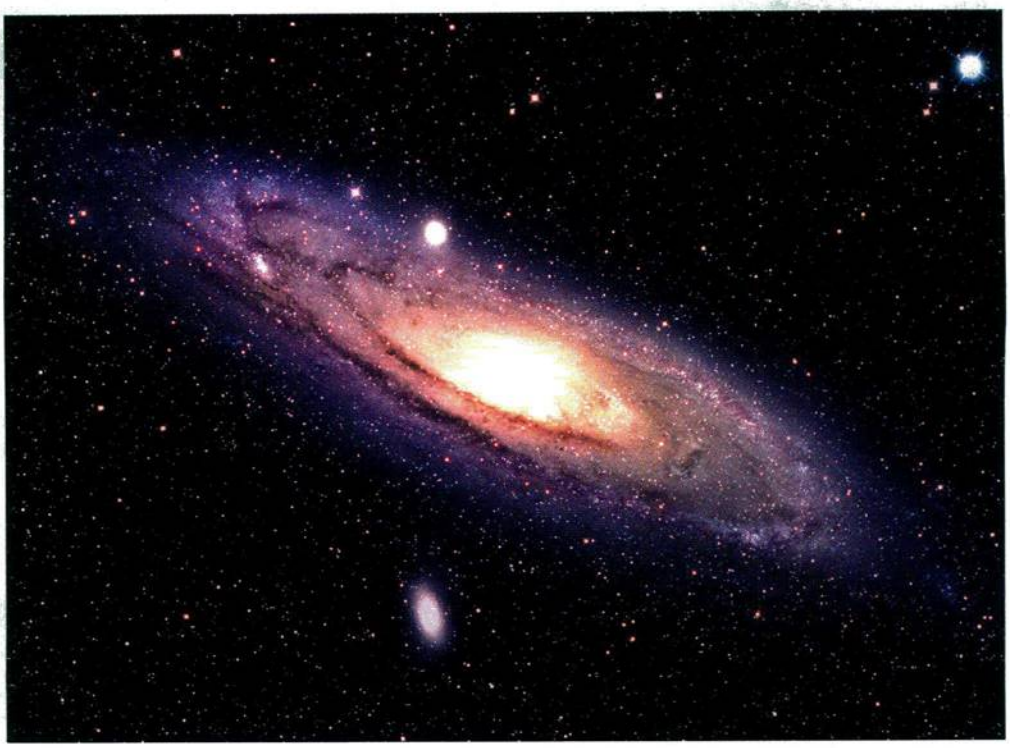
(4-inch refractor, Kodak Royal Gold 100 film, Tokai LPR filter, composite of two 90-minute exposures)

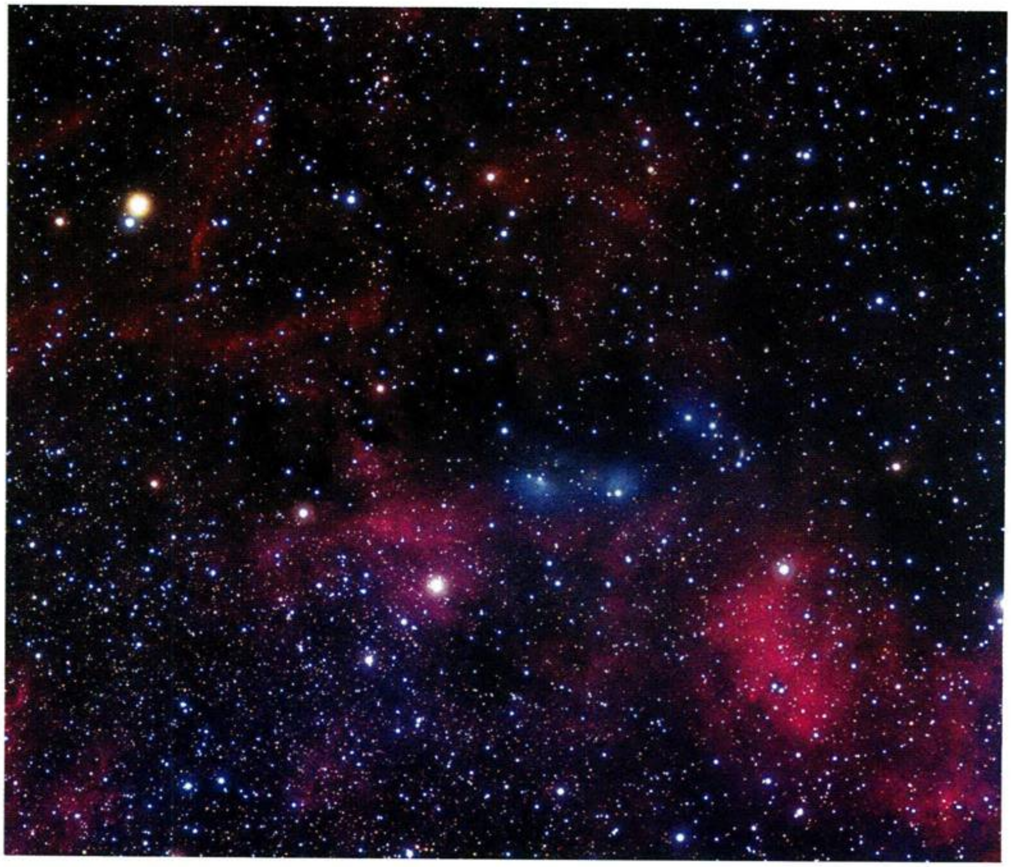
The Andromeda Galaxy

JASON WARE

(12-inch Schmidt camera at f/2.2, composite exposure)







Emission Nebula NGC 6914

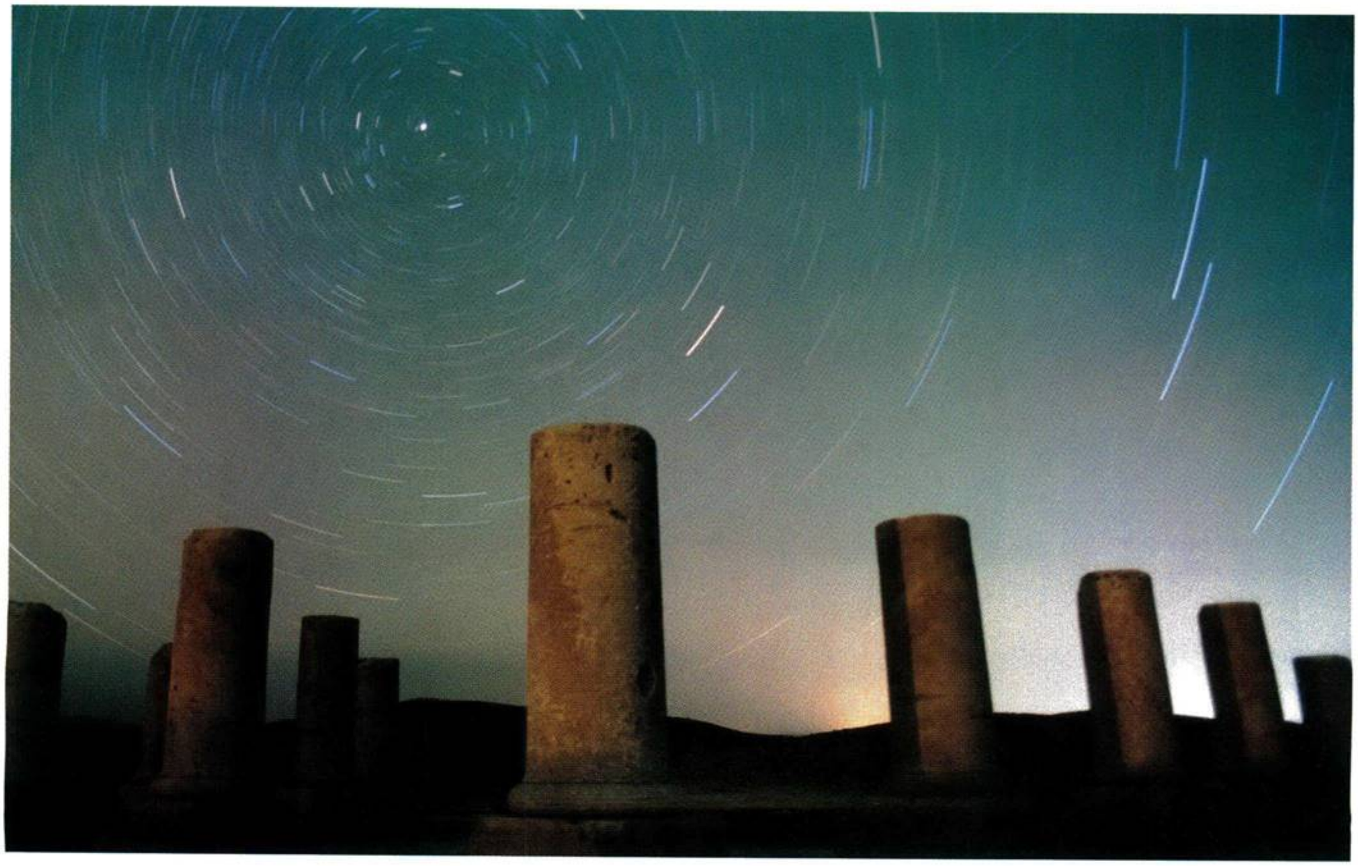
CHUCK VAUGHN

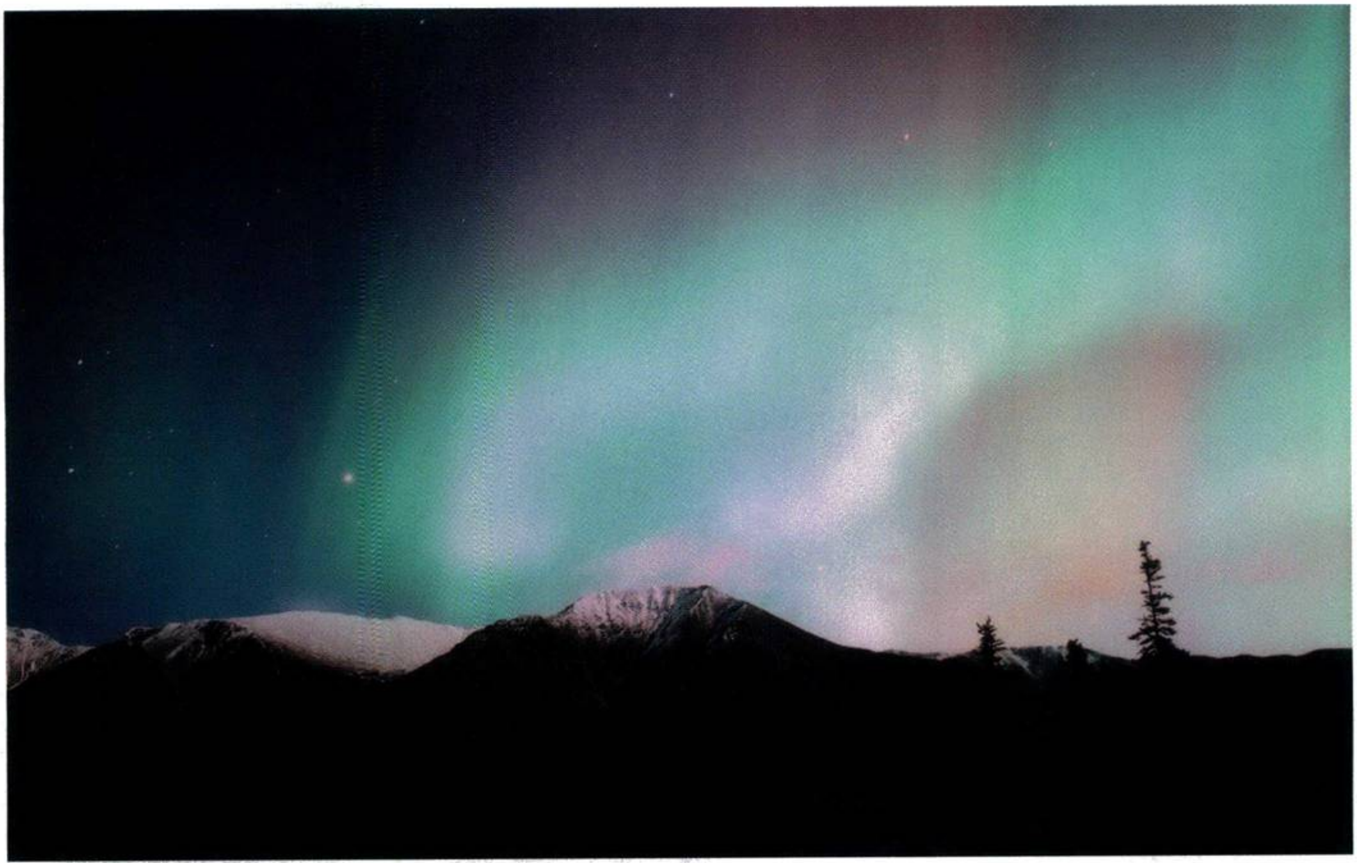
(5-inch refractor at f/8, Tech Pan film, composite tricolor exposure)

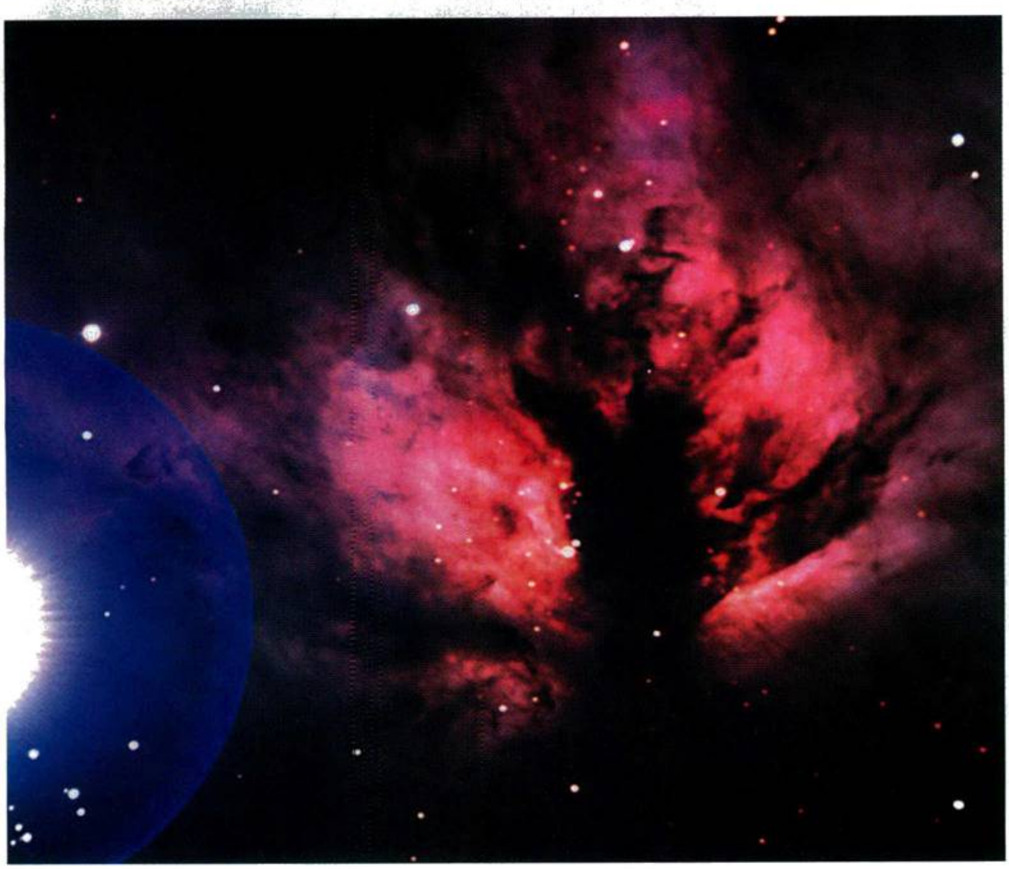
Star Trails over Pasargad, Iran

OSHIN D. ZAKARIAN

(28mm lens at f/4, Fuji Superia X-tra 800 film 60-minute exposure taken at the ruins of the first capital of the Persian Empire)







Bright Alaskan Aurora

MICHAEL KLENSCH

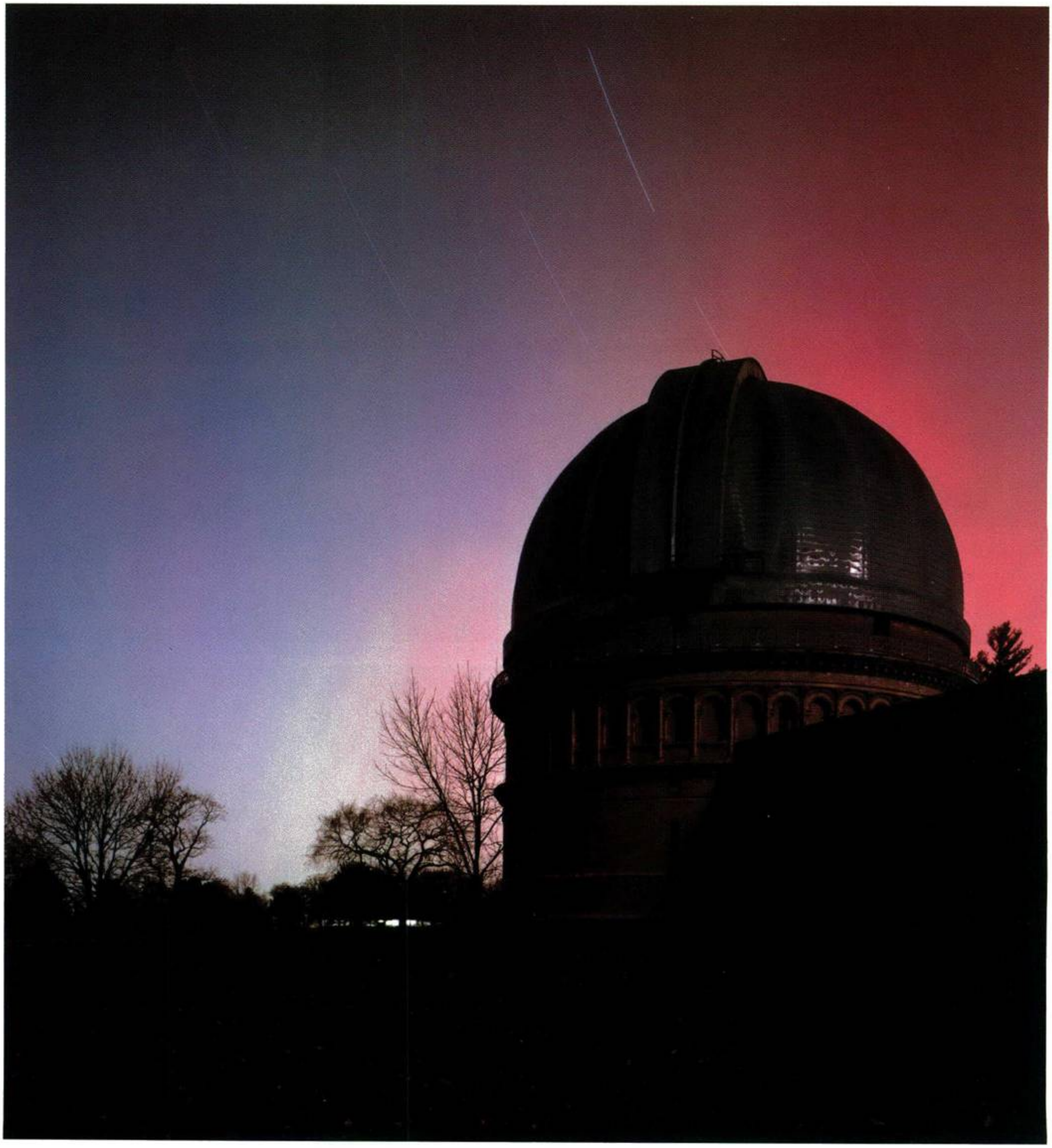
(24mm lens at f/2.8, Fuji Superia 400 film, 15-second exposure taken October 3, 2001)

Emission Nebula NGC 2024

JACK NEWTON

(16-inch SCT at f/10, Finger Lakes Dream Machine CCD camera, composite of three exposures)

This month's best astrophoto



Auroral Show over Yerkes Observatory in Williams Bay, Wisconsin

JON JANZEN

(Taken over the dome of the 40-inch refractor, the largest such telescope in the world, in a simple camera-and-tripod exposure)

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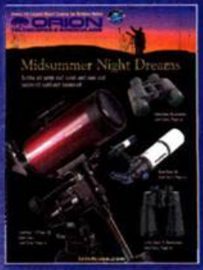

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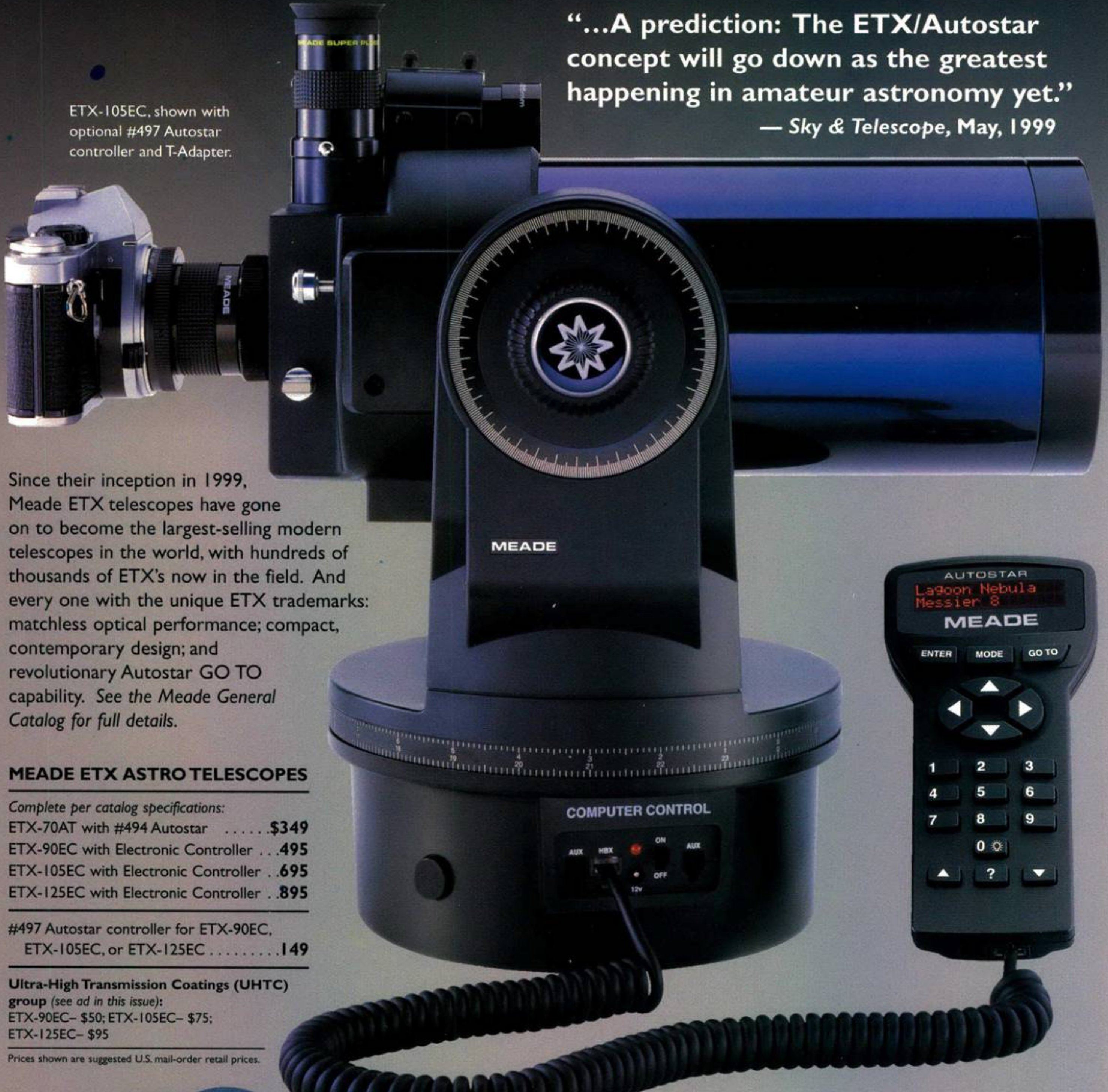

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